ENERGY MANAGEMENT SYSTEMS FOR WEMINDJI, QUEBEC

A Study of Available Options

86-05632/

ENERGY MANAGEMENT SYSTEMS FOR WEMINDJI, QUEBEC

A Study of Available Options

Prepared for:

Sakami Eeyou Corporation

Prepared by:

The SNC Group

With a contribution from:

Remote Community Demonstration Program
of Energy, Mines and Resources Canada

March 1985

RCDP/PDCE-62

This report was prepared with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada (EMR). Distribution of this report by EMR does not necessarily signify that the contents reflect the views and policies of EMR. Mention of trade names and commercial products does not constitute recommendation or endorsement for use.

TABLE OF CONTENTS

PAGE

1.0 SUMMARY vi

RESUME ix

2.0 BACKGROUND 1

3.0 ENERGY DEMAND FORECAST 4

3.1 Introduction 4
3.2 Methodologies of the Energy Demand Forecasts 4
3.3 Comparison of Results 5

4.0 ENERGY SOURCES 11

4.1 Energy Equivalence of Sources 11
4.2 Mini-hydro Management 13
 4.2.1 Principles of Water Management 13
 4.2.2 Water Level Fluctuations 14
4.3 Diesel Generation 21
 4.3.1 Initial Operation 21
 4.3.2 Long Term Operation 25
4.4 Firewood for SHL 25

5.0 ENERGY MANAGEMENT SYSTEMS 27

5.1 Introduction 27
5.2 Forecasting 27
 5.2.1 Mini-hydro Capacity 27
 5.2.2 Energy Demand 28
5.3 Load Management 28
 5.3.1 No Restriction in Electricity Consumption 29
 5.3.2 Domestic Electric Heating in the Summer and the Fall only 29
 5.3.3 Voluntary Control of Electric Heating year-round 30
 5.3.4 Dual Tariff Electricity Metering 31
 5.3.5 Automatic Switching of Electric Heating 31
5.4 Equipment 33

TABLE OF CONTENTS (Cont'd)

		PAGE
6.0	PROPOSED ENERGY MANAGEMENT SYSTEM FOR WEMINDJI	34
6.1	Introduction	34
6.2	Description of Control System	34
6.3	Energy Resource Management	35
	6.3.1 Mini-Hydro	35
	6.3.2 Diesel	37
	6.3.3 Wood	37
	6.3.4 Heating Oil	38
6.4	Forecasting	38
	6.4.1 Mini-Hydro Capacity	38
	6.4.2 Energy Demand	40
	6.4.3 Heating supplied by Mini-Hydro	40
6.5	Operating Procedures	47
	6.5.1 Initial Operation (April to June 1985)	47
	6.5.2 First Year Operation (July 1985 to June 1986)	48
	6.5.3 Long Term Operation	51
7.0	COST ESTIMATES	52
7.1	Electric Plenum Heaters	52
7.2	Baseboard Heaters	52
7.3	Electricity Meters	53
7.4	Automatic Control System	53
8.0	CONCLUSIONS AND RECOMMENDATIONS	54

APPENDICES

Appendix A	TERMS OF REFERENCE	56
Appendix B	ENERGY DEMAND FORECASTS	65
Appendix C	ENERGY SUPPLY AND DEMAND	74
Appendix D	MEETINGS AND PRESENTATION	77
Appendix E	EQUIPMENT	84

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

PAGE
Table 3.1 Comparison of Energy Demand Forecasts 7
Table 3.2 Comparison of Mini-hydro Capability and Energy Demand 8
Table 3.3 Forecast of Basic Electric Load 9
Table 3.4 Mini-Hydro Capability and Energy Demands: 1985 to 1994 10
Table 4.1 Energy Costs 12
Table 4.2 Natural Monthly Flows at Wemindji 15
Table 4.3 Rate of Fill-up/Drawdown of the Reservoir 16
Table 4.4 Electrical Energy Supplied from the Diesel Generators 22
Table 4.5 Capacity and Costs of Firewood 26
Table 6.1 Typical Distribution of Electric Heating 36
Table 6.2 Reservoir Level Versus Storage 39
Table 6.3 Estimated BEL 42
Table 6.4 Estimated SHL FACTOR 44
Table 6.5 Forecast Energy Supply Scenario (July 1985 to June 1986) 50

LIST OF FIGURES

Figure 4.1 Typical Daily Load Curve 18
Figure 4.2 Daily Reservoir Level Fluctuations Induced by Load Variation 19
Figure 4.3 Operating Water Levels 20
Figure 4.4 Monthly Diesel Power Curves 23
Figure 4.5 Monthly Diesel Generation Curves 24
Figure 6.1 Determination of Available Mini-Hydro Energy 41
Figure 6.2 Determination of Total Energy Demand 43
Figure 6.3 Establishment of Heating Energy Management Option 46
Figure 6.4 Forecast Energy Supply and Demand (July 1985 to June 1986) 49

1.0 SUMMARY

The electric supply to Wemindji has been the responsibility of the Department of Indian Affairs and Northern Development (DIAND). The electricity has been supplied by diesel generators and was intended to be used only for the Basic Electric Load (BEL). This is the load that must be supplied by electricity and includes lighting, motors, domestic appliances, etc. In contrast, the Space Heating Load (SHL) can be supplied by a number of energy sources including electricity, oil or wood. There has been considerable use of electric heating at Wemindji as is shown by the typical electric loads in winter which are far in excess of the summer loads, even though the BEL is assumed to be constant throughout the year.

Except for "Third Party Consumers", the consumption of electricity has not been monitored. There are no electricity meters in the homes and there has been no charge for electricity consumption. Within the community many homes are using "free" electric heating, by baseboard heaters, portable heaters or from the stove. There is no tradition of minimizing electricity consumption because of the availability of this electricity.

With the installation of the mini-hydro, the Wemindji community and DIAND will initially take joint responsibility for the electrical energy supply system within the village, including the operation of the mini-hydro and the diesel generators. Long term operation has yet to be decided.

The objectives of this study were to review the existing data on the forecast energy demand and the mini-hydro capacity and to study the options available to manage both the energy supply and the load demand within the community.

Different forecasts for the energy demand at Wemindji were reviewed and compared with the capacity of the Maquatua mini-hydro installation. It was demonstrated that there will be sufficient capacity to supply the BEL and all, or part, of the SHL throughout the year for a number of years in the future. However, there will be periods in the year when the high cost diesel generation must be used unless there is a careful control of electric space heating.

The primary function of the mini-hydro is to supply the BEL for the community, thereby reducing the consumption of oil for diesel generation. Excess mini-hydro capacity will be used to displace oil and wood heating if this does not reduce the capacity to supply the BEL. The mini-hydro generator power output is limited to 1 100 kW even with a full reservoir and maximum river inflow. Also, there will not be sufficient mini-hydro capacity in the winter months to meet the total community energy demand for BEL and SHL.

These operating conditions require a method of controlling the generation and the loads at Wemindji. An Energy Management System (EMS) is required:

- o To ensure that there is sufficient mini-hydro capacity to meet the projected BEL demand for the next operating period
- o To maximize the use of available mini-hydro energy and to avoid, where possible, the spilling of water
- o To minimize the use of diesel generation
- o To displace the use of oil heating as much as possible
- o To ensure fair distribution of the "low-cost" mini-hydro heating energy within the community

Using predicted values for the mini-hydro capacity and for the community electrical load the following operating rules can be applied:

- E_{MH} is greater than (BEL+SHL): Electric heating will be supplied
- E_{MH} is greater than BEL but less than (BEL + SHL) : Limited electric heating will be supplied
- E_{MH} is less than (BEL) : No electric heating will be supplied

It will be necessary to manage the overall electric load within the community for several months of the year even in the early years. Later, load management will be essential year-round.

At the generating station there is no way of distinguishing between electricity used for BEL and electricity used for SHL. Some means must be found to control electrical heating at the consumer location and this applies to domestic, commercial or institutional consumers.

A number of management options are reviewed:

- No restriction in electricity consumption
- Domestic electrical heating in the summer and fall months only
- Voluntary switching of electric space heating
- Dual tariff electricity metering

- Automatic switching of electric space heating

At a general community meeting a number of EMS options were reviewed and discussed. It was decided that a voluntary EMS would be adopted and that, when necessary, the domestic consumers would switch from electric heating to wood or oil when requested to do so by the operators.

The first period of operation for the first few months until early summer, 1985, will be non-typical. Winter commissioning of the mini-hydro has resulted in the presence of downstream ice which reduces the maximum power output of the mini-hydro to approximately 600 kW. This coincides with the period of minimum energy capacity due to the reduced river inflow. Also, it is not possible with the present temporary arrangement to synchronise the existing diesel generators onto the system with the mini-hydro connected. These difficulties will be removed from mid-May onwards, but until that time the diesel unit will be permanently connected to the system and will supply the difference between the total community demand and the mini-hydro output. There may therefore be a greater consumption of diesel fuel than would be expected in later years.

The second period will be the first full operating season from summer 1985 to summer 1986. By this time the combined mini-hydro/diesel powerhouse will be commissioned and the operators will be familiar with the techniques of managing the mini-hydro output, forecasting load demands and controlling the electric heating load. The community will have gained experience in the voluntary control of electric heating and with the requirement to switch to oil or wood when required. Following this period, the EMS will be reviewed by the Management Committee to determine if any changes are required.

SYSTÈMES DE GESTION DE L'ÉNERGIE POUR WEMINDJI (QUÉBEC)

Une étude des options disponibles

Résumé

Le ministère des Affaires indiennes et du Nord canadien est responsable de l'approvisionnement en électricité pour Wemindji. L'électricité était fournie par des génératrices diesel et ne devait servir que pour la charge électrique de base (C.E.B.). Il s'agit de la charge qui doit être fournie par l'électricité et cela comprend l'éclairage, les moteurs, les appareils ménagers, etc. Par contre, la charge de chauffage des locaux (C.C.L.) peut provenir de diverses sources énergétiques y compris l'électricité, le mazout ou le bois. On a beaucoup utilisé le chauffage à l'électricité à Wemindji, comme on peut le voir par les charges électriques typiques en hiver, qui sont beaucoup plus élevées que les charges d'été, même si l'on assume que la charge électrique de base est constante tout au long de l'année.

Sauf pour les "tiers consommateurs", la consommation d'électricité n'a pas été contrôlée. Il n'y a pas de compteurs électriques dans les résidences et il n'y a pas eu de frais pour la consommation d'électricité. Dans la collectivité plusieurs résidences utilisent le chauffage gratuit à l'électricité, soit au moyen de plinthes électriques, de chaufferettes portatives ou de cuisinières. Il n'existe aucune tradition de réduction de la consommation d'électricité étant donné la disponibilité de cette électricité.

Avec l'installation de la mini-centrale, la collectivité de Wemindji et le ministère des Affaires indiennes et du Nord Canada prendront d'abord la responsabilité de façon conjointe pour les systèmes d'alimentation en électricité dans le village, y compris l'exploitation de la mini-centrale et des génératrices diesel. Rien n'a encore été décidé quant à l'exploitation à long terme.

Le but de cette étude était d'analyser les données actuelles sur la demande énergétique prévue et sur la capacité de la mini-centrale, et d'étudier les options disponibles pour gérer l'alimentation énergétique et la demande de charge dans la collectivité.

On a étudié diverses prévisions de la demande énergétique à Wemindji et on les a comparées à la capacité de la mini-centrale de Maquatua. On a démontré qu'il y aurait suffisamment de capacité pour alimenter la charge électrique de base et toute la charge de chauffage des locaux ou du moins une partie de celle-ci pendant toute l'année, pour un certain nombre d'années. Cependant, il y aura certaines périodes pendant l'année où il faudra utiliser l'énergie au diesel qui coûte cher, à moins d'avoir un contrôle serré du chauffage des locaux à l'électricité.

La fonction principale de la mini-centrale est d'alimenter la charge électrique de base pour la collectivité, réduisant ainsi la consommation de mazout pour la production de diesel. La capacité excédentaire de la mini-centrale sera utilisée pour remplacer le chauffage au mazout et au bois si cela ne réduit pas la capacité pour alimenter la charge électrique de base. La production de la mini-centrale est limitée à 1 100 kW, même avec un réservoir plein et l'affluence maximale de la rivière. En outre, la mini-centrale n'aura pas la capacité suffisante au cours des mois d'hiver pour répondre à la demande énergétique totale de la collectivité pour la charge électrique de base et la charge de chauffage des locaux.

Ces conditions d'exploitation demandent une méthode de contrôle de la production et des charges à Wemindji. On a besoin d'un système de gestion de l'énergie:

- pour s'assurer que la centrale a la capacité pour satisfaire à la demande de charge électrique de base prévue pour la prochaine période d'exploitation;

- pour maximiser l'utilisation de l'énergie de la mini-centrale disponible et pour éviter, lorsque possible, que l'eau se déverse;

- pour minimiser l'utilisation de l'énergie diesel;

- pour remplacer le chauffage au mazout le plus possible;

- pour assurer une distribution équitable de l'énergie de chauffage de la mini-centrale à un coût peu élevé dans la collectivité.

En utilisant les valeurs prévues pour la capacité de la mini-centrale (C.M.-C.) et pour la charge électrique de la collectivité, on peut appliquer les règles d'exploitation suivantes:

- C.M.-C. est plus grande que (C.E.B. + C.C.L.):	Le chauffage électrique sera fourni;
- C.M.-C. est plus grande que C.E.B. mais moindre que (C.E.B. + C.C.L.).	Le chauffage électrique limité sera fourni;
- C.M.-C. est moindre que (C.E.B.)	Aucun chauffage à l'électricité ne sera fourni.

Il sera nécessaire d'administrer la charge électrique totale pour la collectivité pendant plusieurs mois de l'année, même au cours des premières années. Plus tard, la gestion de la charge sera essentielle tout au long de l'année.

À la centrale, il n'y a aucune façon de faire la distinction entre l'électricité utilisée pour la charge électrique de base et l'électricité utilisée pour la charge de chauffage des locaux. Il faut trouver des moyens de contrôler le chauffage électrique chez le consommateur et ceci s'applique aux consommateurs domestiques, commerciaux ou institutionnels.

On étudie plusieurs options de gestion:

- Aucune restriction dans la consommation d'électricité;
- Le chauffage électrique domestique pendant les mois d'été et d'automne seulement;
- Changement volontaire du chauffage des locaux à l'électricité;
- Le comptage électrique à deux tarifs;
- Le changement automatique du chauffage des locaux à l'électricité.

Lors d'une réunion générale de la collectivité on a discuté de plusieurs options pour un système de gestion de l'énergie. Il a été décidé que l'on adopterait un système de gestion de l'énergie volontaire et qu'au besoin les consommateurs domestiques passeraient du chauffage à l'électricité au chauffage au mazout ou au bois lorsque les exploitants le leur demanderaient.

La première période d'exploitation, pendant les premiers mois, soit jusqu'au début de l'été 1985, ne sera pas typique. La mise en service de la mini-centrale en hiver a eu pour conséquence la formation de glace descendant la rivière ce qui réduit la production maximale d'énergie de la mini-centrale à environ 600 kW. Ceci coincide avec la période de capacité minimale énergétique étant donné l'affluence réduite dans la rivière. En outre, il n'est pas possible, avec les dispositions temporaires actuelles, de synchroniser les génératrices diesel actuelles au système, la mini-centrale étant branchée. Ces difficultés seront éliminées à partir de la mi-mai mais d'ici là, l'unité diesel sera branchée de façon permanente au système et fournira la différence entre la demande totale de la collectivité et la production de la mini-centrale. Par conséquent, il est possible qu'il y ait une plus grande consommation de combustible diesel que celle prévue pour les années à venir.

La deuxième période sera la première saison d'exploitation complète, de l'été 1985 à l'été 1986. D'ici, là, la centrale combinée hydro-diesel sera mise en service et les exploitants se seront familiarisés avec les techniques de gestion de la production de la mini-centrale, la prévision des demandes de charge et le contrôle de la charge de chauffage électrique. La collectivité aura acquis de l'expérience du contrôle volontaire du chauffage électrique et du besoin de passer au mazout ou au bois lorsque c'est nécessaire. Après cette période, le Comité de gestion étudiera à nouveau le système de gestion de l'énergie pour déterminer s'il y a lieu de faire des changements.

Cette étude a été effectuée par Sakami Eeyou Corp. par SNC avec une subvention du Programme de démonstration dans les collectivités éloignées d'Énergie, Mines et Ressources Canada.

2.0 BACKGROUND

The Basic Electric Load (BEL) at Wemindji is approximately 25% of the total community load. Recent estimates (Ref. 3) put the BEL for 1985 at 1 960 MWh/annum with a mean load of 230 kW. Until the construction of the mini-hydro generation on the Maquatua river, the BEL was supplied by diesel generation, owned and operated by the Department of Indian Affairs and Northern Development (DIAND). The diesel generation was originally intended to supply only the BEL for public buildings and services, but over the years the generation and distribution system has been expanded to supply each home in the community.

In addition to supplying the BEL, some of the Space Heating Load (SHL) is being supplied by electricity. This is shown by the seasonal variation in electricity demand which varies by more than 60% between July and January, even though the BEL is assumed to be constant throughout the year.

With an average annual temperature of -4°C, more than 7 600 heating degree days and minimum temperatures of -40°C, the SHL represents 75% of the overall energy demand at Wemindji. The estimates from Reference 3 indicate that the SHL for 1985 will be 5 710 MWh/annum. Until the installation of the mini-hydro, this heating demand was supplied by a combination of low cost wood, high cost heating oil and even higher cost diesel generation.

The mini-hydro has been installed to minimize consumption of oil used for electricity generation and heating. It's prime function is to supply the BEL for the community. Only if there is sufficient capacity will all or part of the SHL be supplied from the mini-hydro, provided that this does not reduce the reservoir level and thereby limit the capability to supply the BEL in the next operating period.

The rated maximum output of the generator is 1 100 kW. If the community load is greater than 1 100 kW, either the diesel generators must be operated in parallel with the mini-hydro or the load must be reduced. Otherwise, the voltage and frequency will be reduced to the point where the generator will be disconnected by its protection circuits.

The energy available from the mini-hydro depends on the water stored in the reservoir and the river inflow. In the summer months the river inflows will normally be sufficient to run the generator at its rated output of 1 100 kW for 24-hours a day; even then it will be necessary to "spill water". In the winter months, especially February, March and April, the river inflows are reduced so that the continuous generator output may be limited to between 200 kW to 400 kW. Otherwise, the reservoir level will be reduced to its minimum level and the mini-hydro will be disconnected.

Therefore, the capability of the mini-hydro to supply the BEL and the SHL will vary with the season. The Wemindji community recognised the need to manage both the mini-hydro generation and the community electric load. In this way the maximum benefits will be obtained from the resource and the overall energy costs will be minimized. It was also decided that a number of previous related studies and evaluations on the energy demand forecasts and energy sources should be reviewed to assess their impact on the management of the energy supply and energy demand within the community.

In October 1984, SNC was requested to carry out "A Study of the Available Energy Management System Options". A copy of the Terms of Reference is included in this report as Appendix A. The main aspects in the Scope of Work are summarised below:

o Review of existing data:	To include energy demand forecasts, energy conservation (benefits and costs), fire wood for SHL, diesel generation, mini-hydro capabilities.
o Mini-hydro operation:	An evaluation of the different scenarios to optimise the mini-hydro capability.
o Community energy demand:	The use of existing studies to determine the energy demand forecast to the year 2032.
o Energy Management Systems:	A review of the options available for EMS with the benefits and drawbacks.
o Recommended EMS:	To recommend the EMS for Wemindji, following consultation with the Management Committee and the community.

In section 3.0 the Energy Demand Forecasts are reviewed to assess their impact on the EMS for Wemindji. In Section 4.0 the Energy Sources are discussed, principally mini-hydro, firewood and diesel generation. In Section 5.0 the Energy Management System options are reviewed as they would aply to Wemindji. In Section 6.0 the EMS for Wemindji is described in detail, both for the short-term and the long-term operating conditions. The cost estimates for the various equipment are given in Section 7.0 and finally the principal Conclusions and Recommendations are presented in Section 8.0.

3.0 ENERGY DEMAND FORECAST

3.1 Introduction

Three sources of data were reviewed to establish an energy demand forecast for Wemindji to the year 2032.

- The 1982 SNC Report "Wemindji Energy Study" and subsequent updates (Ref. 1)
- The 1984 Cogesult Report: "Firewood Report" (Ref. 2)
- The 1984 RSW Report: "Wemindji Energy Review" (Ref. 3)

It was decided at an October 1984 meeting of the Energy Management System (EMS) Coordination Committee that the three reports contained sufficient data to give an energy demand forecast of acceptable accuracy for the EMS study. Therefore, no further data gathering was undertaken.

Reference 1 and Reference 3 considered the Basic Electric Load (BEL) and the total Space Heating Load (SHL) for Domestic, Institutional and Commercial heating demands. The forecast planning period was to the year 2032.

Reference 2 considered only domestic heating requirements; it did not consider the Commercial or Institutional SHL or the BEL of the community. The forecast planning period was to the year 2013.

The results of the three energy forecasts are given in Appendix B.

3.2 Methodologies of the Energy Demand Forecasts

Reference 1

The objective of the original SNC studies was to determine the optimum mix of energy sources for Wemindji for forecast planning periods to the year 2032. Estimates were made of the energy demand for the BEL and the SHL, using published "typical data." Population growth forecasts and building expansion plans were used to project increases in energy demand. Future occupancy rates of 5-people per home, plus replacement of older, inefficient homes was assumed. Detailed energy audits were not performed but impact of any inaccuracies in the energy demand forecast was determined by a series of sensitivity analyses.

Reference 2

Detailed energy audits were conducted of a representative sample of homes in three communities, including Wemindji. The study took into account the energy gains from the occupants, electrical appliances and passive solar heating. These energy gains were subtracted from the calculated heating requirements for the different homes. Only the domestic SHL was determined. The BEL was not considered, nor was the SHL for public buildings. The forecast growth in energy demand assumed replacement of older homes by new models and construction of new homes in groups of 15. No account was taken of the increases in energy demand for BEL or for public SHL. The planning period was to the year 2013.

Reference 3

This was a review and analysis of existing data from references 1 and 2 and from other published data. The estimates for BEL were based on the original SNC studies, updated to allow for new loads such as the Arena, the trace heating of water pipes and the airstrip. The predicted increases in BEL and SHL energy demands were based on population growth forecasts and building programs. The planning period was to the year 2032.

3.3 Comparison of Results

When comparing the three projections of the Wemindji load growth it is important to realize that there were different objectives for each of the studies.

In the first series of studies (reference 1), the objective was to determine the optimum energy supply scenario for the community for the next 50-years. An approximate estimate was made of the BEL and the SHL by using existing criteria for similar communities, coupled with the building expansion program required to meet the forecast population growth. It was acknowledged that there would be inaccuracies in the energy demand forecasts and this was taken into account by the use of sensitivity analyses which varied the energy demand forecasts by up to 100%.

The objective of the second study (reference 2) was to determine the availability and costs of supply of firewood for the domestic heating demands of a number of communities, including Wemindji. Detailed energy audits were carried out of typical homes in the community. The future building program was estimated by taking into account the population growth and the replacement of the older homes by new, energy efficient homes.

The mandate of the final review (reference 3) was to evaluate existing data and reports, especially references 1 and 2, and to comment on the viability of the Mini-hydro as the principal electrical energy source for Wemindji. The energy demand forecasts were reviewed to give estimates of the BEL and the SHL energy demands for Wemindji to the year 2032.

The three energy demand forecasts are compared in Table 3.1.

- For the year 1984, the estimates for the total community energy demand in reference 2 and reference 3 agree to within 5% (6 705 MWh compared with 6 400 MWh).
- By the year 1994, the difference in the projections for the total community energy demand has increased to 24% (7 920 MWh and 9 780 MWh).
- By the year 2013, difference between the two estimates is 30% (10 800 MWh compared to 13 890 MWh).

From the viewpoint of the EMS study, a more important comparison is given in Table 3.2 which compares the projected energy demands and the mini-hydro energy capacity in a typical year. The total monthly energy demand will exceed the mini-hydro capacity for December through April even in the early years of the project. By the year 2013, the total monthly energy demand will be greater than the mini-hydro capacity from October through May.

This conclusion is reached for the energy demand forecasts in references 1, 2 and 3. Each demonstrates the requirement for an Energy Management System (EMS) to optimize the use of the available mini-hydro energy.

The actual energy demand for BEL and SHL will not be exactly as forecast in any of the projections due to variations in the building program and usage patterns within the community, plus weather changes. However, short-term projections can be used as a starting point from which the operators can establish the energy demands throughout the year. In Table 3.4, the projected BEL and SHL are given for the first 10-years of operation (1985 to 1994).

TABLE 3.1

COMPARISON OF ENERGY DEMAND FORECASTS

		ENERGY DEMAND PER ANNUM (MWh)				
		1984	1994	2004	2013	2032
RESIDENTIAL SHL	ref.1	4 520	7 550			19 930
	ref. 2	2 860	2 830	3 510	4 410	----
	ref. 3	2 560	4 690	6 140	7 500	10 450
OVERALL SHL	ref.1	6 400	10 080	12 800	15 590	23 180
	ref.3	4 440	7 265	8 960	10 470	13 700
BEL	ref.1	940	1 580	2 120	2 660	4 100
	ref.3	1 960	2 520	2 920	3 430	4 660
TOTAL ENERGY DEMAND (1)	ref.1	7 340	11 660	14 920	18 250	27 280
	ref.2	6 700	7 920	9 240	10 800	-----
	ref.3	6 400	9 780	11 880	13 890	18 360

Note: (1) Assumes the calculated BEL for RSW report (ref.3)

(2) Figures rounded: e.g. 4523 4520; 4656 4660

TABLE 3.2

COMPARISON OF MINI-HYDRO CAPABILITY AND ENERGY DEMAND FORECASTS

(All quantities given in Mwh)

	MINI-HYDRO CAPACITY	1984			1994			2004			2013			2032	
		BEL	TOTAL DEMAND (Ref.2)	TOTAL DEMAND (Ref.3)	BEL	TOTAL DEMAND (Ref.2)	TOTAL DEMAND (Ref.3)	BEL	TOTAL DEMAND (Ref.2)	TOTAL DEMAND (Ref.3)	BEL	TOTAL DEMAND (Ref.2)	TOTAL DEMAND (Ref.3)	BEL	TOTAL DEMAND (Ref.3)
JAN.	430	160	940	1 080	210	1 090	1 400	240	1 280	1 700	290	1 490	2 000	390	2 630
FEB.	280	160	840	960	210	980	1 250	240	1 150	1 520	290	1 340	1 780	390	2 340
MARCH	250	160	810	920	210	940	1 190	240	1 100	1 460	290	1 280	1 700	390	2 240
APRIL	300	160	610	680	210	710	890	240	830	1 080	290	970	1 260	390	1 660
MAY	800	160	460	510	210	540	660	240	630	790	290	740	930	390	1 230
JUNE	800	160	330	360	210	400	470	240	470	560	290	550	660	390	880
JULY	800	160	270	290	210	330	380	240	390	450	290	460	530	390	700
AUG.	800	160	290	310	210	360	400	240	410	480	290	480	570	390	760
SEP.	800	160	350	380	210	420	490	240	490	590	290	570	700	390	920
OCT.	800	160	450	500	210	530	640	240	620	780	290	730	910	390	1 210
NOV.	800	160	580	650	210	680	850	240	800	1 030	290	930	1 200	390	1 590
DEC.	800	160	790	900	210	930	1 170	240	1 080	1 430	290	1 260	1 670	390	2 200

TABLE 3.3

FORECAST OF BASIC ELECTRICAL LOAD

YEAR	MEAN LOAD (kW)	DAILY PEAK LOAD (kW)
1985	230	455
1986	240	470
1987	245	480
1988	250	500
1989	255	520
1990	255	540
1991	270	555
1992	275	590
2007	340	820
2032	520	1 250

TABLE 3.4

PROJECTED MINI-HYDRO CAPABILITY AND COMMUNITY ENERGY DEMANDS: 1985 TO 1994

MONTH	MINI-HYDRO CAPACITY (Mwh)	1985		1986		1987		1988		1989		1990		1991		1992		1993		1994	
		BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh)	BEL (Mwh)	SHL (Mwh
JANUARY	430	170	930	180	950	180	1 040	190	1 050	190	1 070	195	1 100	200	1 130	205	1 140	210	1 170	210	1 190
FEBRUARY	280	170	815	180	830	180	910	190	920	190	930	195	960	200	980	205	1 000	210	1 020	210	1 040
MARCH	250	170	770	180	790	180	860	190	870	190	880	195	910	200	930	205	940	210	970	210	980
APRIL	300	170	530	180	540	180	590	190	600	190	610	195	630	200	640	205	650	210	670	210	680
MAY	800	170	350	180	360	180	390	190	400	190	400	195	410	200	420	205	430	210	440	210	450
JUNE	800	170	200	180	210	180	230	190	230	190	230	195	240	200	250	205	250	210	260	210	260
JULY	800	170	130	180	130	180	150	190	150	190	150	195	150	200	160	205	160	210	160	210	170
AUGUST	800	170	150	180	160	180	170	190	170	190	180	195	180	200	190	205	190	210	190	210	190
SEPTEMBER	800	170	220	180	230	180	250	190	250	190	260	195	260	200	270	205	270	210	280	210	280
OCTOBER	800	170	340	180	350	180	380	190	380	190	390	195	400	200	410	205	420	210	430	210	430
NOVEMBER	800	170	500	180	510	180	560	190	570	190	570	195	590	200	610	205	610	210	630	210	640
DECEMBER	800	170	755	180	770	180	840	190	850	190	870	195	890	200	910	205	930	210	950	210	960
TOTALS	7 660	2 040	5 690	2 160	5 830	2 160	6 370	2 280	6 440	2 280	6 540	2 340	6 720	2 400	6 900	2 460	6 990	2 520	7 170	2 520	7 270

4.0 ENERGY SOURCES

A number of energy sources are available at Wemindji to supply the Basic Electric Load (BEL) and the Space Heating load (SHL) for domestic and Public buildings.

. Mini-Hydro	for BEL and SHL
. Diesel	for BEL and SHL
. Heating Oil	for SHL
. Wood	for SHL

For the purposes of this review, Solar and Wind generation are not considered.

Mini-hydro and wood are renewable resources and provide the lowest cost fuel. The use of oil for diesel generation and for home heating should be minimized as far as possible.

4.1 Energy Equivalence of Sources

The equivalence of Water, Wood and Oil as energy sources is given below:

- One litre of Oil for Heating has a theoretical heat content of 10.7 kWh. Assuming an average furnace efficiency of 70% this will be equivalent to an energy supply of 7.5 kWh/litre.
- One litre of Oil for Diesel generation with an assumed overall efficiency of 28% has a theoretical electrical energy output of 3.0 kWh/litre.
- One full cord of dry wood (4ftx4ftx8ft) has a theoretical heat content of 5 000 kWh. Assuming an average furnace efficiency of 60% this will be equivalent to an energy supply of 3 000 kWh/cord.
- One cubic metre/second of water flowing for one hour through the mini-hydro, with an average head of 10 m and an assumed overall efficiency of 85%, will have an energy equivalent to 83.0 kWh.

The most recent estimates of the costs of energy are given in Table 4.1.

TABLE 4.1

ENERGY COSTS

ENERGY SOURCE	ENERGY OUTPUT	FUEL COSTS	ENERGY COSTS (¢/kWh)
HEATING OIL	7.5 kWh/litre	72 ¢/litre	9.6
DIESEL ELECTRICITY (1)	3.0 kWh/litre	45 ¢/litre	35.0
WOOD HEATING (4)	3 000 kWh/cord	60 $/cord	2.0
(5)	3 240 kWh/cord	105 $/cord	3.2
MINI-HYDRO ELECTRICITY	83 kWh/m³/s (2)	0	1.2 (3)

Notes: (1) Telephone conversation with DIAND (Mr. Bundock) on the 7th February 1985 (cost including maintenance and operation).

(2) One hour's generation with 10 m head.

(3) Ignores Capital costs since plant is already installed. Assumes operating and maintenance costs of $70,000/annum and 6.0 million kWh generated per annum on the average.

(4) 5 000 kWh/cord and 60% efficiency: Fuel costs supplied by Band Council.

(5) From Ref. 2 including an overall efficiency of 65%.

The energy costs for the different energy sources show clearly the need to maximize the use of the mini-hydro generation to supply the BEL and the SHL. In addition, the very high costs of diesel generation show that the mini-hydro capacity should be conserved, when necessary, so that there is sufficient capability to supply the projected BEL.

4.2 Mini-Hydro Management

The maximum power output from the mini-hydro is 1 100 kW, regardless of the reservoir storage level. The peak BEL demand is forecast to increase from 455 kW in 1985 to 1 250 kW in 2032 (Table 3.3). Therefore the peak heating load supplied by mini-hydro will be limited in 1985 to 645 kW (1 100 kW - 455 kW) and there will be a gradual reduction in the SHL supplied by the mini-hydro in future years.

In addition, there will be times during the year when there will be insufficient energy available from the mini-hydro to meet the total community energy demand (see Table 3.2).

Therefore, the mini-hydro output will be governed by several factors, including:

- BEL power and energy required for the next operating period.
- Water inflow projected for the next operating period
- Actual reservoir level

The operators will manage the electric heating so as to maintain the total community load (BEL + SHL) at 1 100 kW, or less, and to ensure that there will be sufficient energy to supply the forecast BEL for the next operating period.

4.2.1 Principles of Water Management

The natural water inflow during a day will be more or less constant, unless there is a heavy and concentrated rainstorm.

If there is a water inflow quantity of "Q" cubic metres per second (Q m^3/s) the mini-hydro electrical energy (E_{MH}) generated in one day will be:

$$\text{Energy per day } (E_{MH}) = 2\ 000 \times Q \text{ kWh}$$

Note: The maximum mini-hydro energy output is limited to 1 100 kW. Any water flows in excess of 12.1 m^3/s (or above the maximum power output) will be spilled. Therefore the maximum daily energy output for flows greater than or equal to 12.1 m^3/s will be 26 400 kWh (24 hour x 1 100 kWh).

The following rules apply to the water management of the mini-hydro:

- If the river inflow (Q) is greater than 12.1 m^3/s, the reservoir will fill and water will eventually spill over the dam. This is independent of the community load demand. No water management is possible.
- If the energy capability of the mini-hydro (2 000 X Q) is greater than the total community energy demand for the day (BEL+SHL), the reservoir will fill and excess water will eventually spill. No water management is possible.
- If the mini-hydro capability (2000 X Q) is greater than the BEL but less than the total community energy demand for the day (BEL+SHL) the reservoir level will decrease and, unless action is taken to reduce the load, the mini-hydro will eventually shut down. Water management is necessary.
- If the mini-hydro capability (2000 X Q) is lower than the BEL, diesel generation will be necessary in parallel with the mini-hydro. Careful control will minimize the diesel generation required. Water management is necessary.

4.2.2 Water Level Fluctuation

The variation in the water levels in the mini-hydro reservoir will depend on the river inflow and the mini-hydro output. Therefore, since the rate of water inflow will be constant throughout any typical day, the rate of water drawdown or fill-up will depend on the load demand being met by the mini-hydro.

Table 4.2 shows the projected natural monthly inflows at Wemindji for typical years, and for the high-flow and low-flow years.

Table 4.3 shows how the actual rate of drawdown will depend on the river inflow and the total electrical load being supplied by the mini-hydro.

As an example, Table 4.2 shows that the mean monthly flow for February is 4.98 m^3/s (say 5 m^3/s). Table 4.3 then shows that a load of 400 kW could be supplied continuously without drawdown of the reservoir. Increasing the load to 1 000 kW would result in a drawdown of 11.5 cm/hour which would reduce the reservoir in a

TABLE 4.2

NATURAL MONTHLY FLOWS AT WEMINDJI

MONTH	MEAN (m^3/s)	1/10 YEAR HIGH FLOW (m^3/s)	1/10 YEAR LOW FLOW (m^3/s)
January	6.99	9.30	5.26
February	4.98	6.34	3.91
March	4.06	5.12	3.22
April	4.91	9.64	2.61
May	35.76	54.63	23.32
June	27.51	44.49	17.08
July	17.81	28.24	11.33
August	17.50	34.25	8.96
September	18.53	34.12	10.10
October	23.57	43.42	12.79
November	19.26	30.86	12.05
December	12.28	17.79	8.48

TABLE 4.3

RATE OF FILL UP/DRAWDOWN OF THE RESERVOIR
Rates are expressed in cm/h

Mini-hydro output (kW)	Natural river inflow (m^3/s)									
	3	4	5	6	7	8	9	10	11	12
0	5.0	6.6	8.3	7.9	11.6	13.2	14.9	16.5	18.2	19.8
150	-0.1	1.6	3.2	4.9	6.5	8.2	9.8	11.5	13.1	14.8
200	-0.9	0.8	2.5	4.1	5.8	7.4	7.1	10.7	12.4	14.0
300	-2.0	-0.3	1.3	3.0	4.6	6.3	7.9	9.6	11.2	12.9
400	-3.2	-1.5	0.1	1.8	3.4	5.1	6.7	8.4	10.0	11.7
500	-4.8	-3.1	-1.5	0.2	1.9	3.5	5.2	6.8	8.5	10.1
600	-6.6	-4.9	-3.3	-1.6	0.0	1.7	3.3	5.0	6.6	8.3
700	-8.5	-6.8	-5.2	-3.5	-1.9	-0.2	1.4	3.1	4.7	6.4
800	-10.4	-8.8	-7.1	-5.5	-3.8	-2.2	-0.5	1.1	2.8	4.4
900	-12.5	-10.9	-9.2	-7.6	-5.9	-4.3	-2.6	-1.0	0.7	2.3
1000	-14.8	-13.1	-11.5	-9.8	-8.2	-6.5	-4.9	-3.2	-1.6	0.1
1050	-16.0	-14.3	-12.7	-11.0	-9.4	-7.7	-6.1	-4.4	-2.8	-1.1

Note: Negative values (e.g. - 3.2 cm/hr) indicate a drawdown of the reservoir.

matter of hours, to a level where the mini-hydro must be shutdown.

A typical load curve for a remote community is shown in Figure 4.1. The timing of daily peaks will depend on the domestic load demands for cooking, heating, etc., because the commercial, industrial and institutional demands for remote communities are a small percentage of the total. The operators will measure the actual daily load curves at Wemindji for various times of the year.

In Figure 4.2 the projected 1988 daily BEL curve for Wemindji is shown together with the resulting fluctuations in the reservoir water level. In this example, the normal daily water level fluctuations would be around 0.3 m for a peak demand of 500 kW.

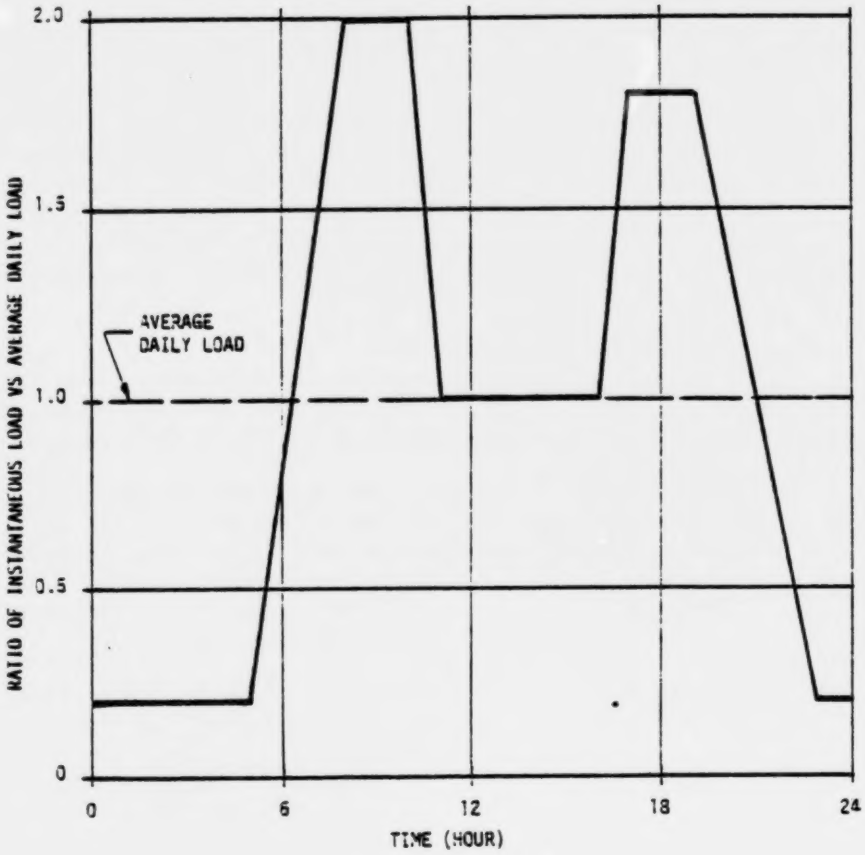
The Maquatua mini-hydro system has been designed for optimum operation with a number of important water level and drawdown limits. The different water levels are shown in Figure 4.3.

Level A:	The maximum reservoir level during flood periods
Level B:	The maximum reservoir level before spill occurs
Levels C & E:	The limits between which the reservoir will vary during periods of water management
Level D:	The average reservoir level desired during water management
Level F:	The minimum permissible reservoir level, below which the mini-hydro must be shut down.

Level A (43.2 m) and Level B (41.0 m) are imposed by the mini-hydro design.

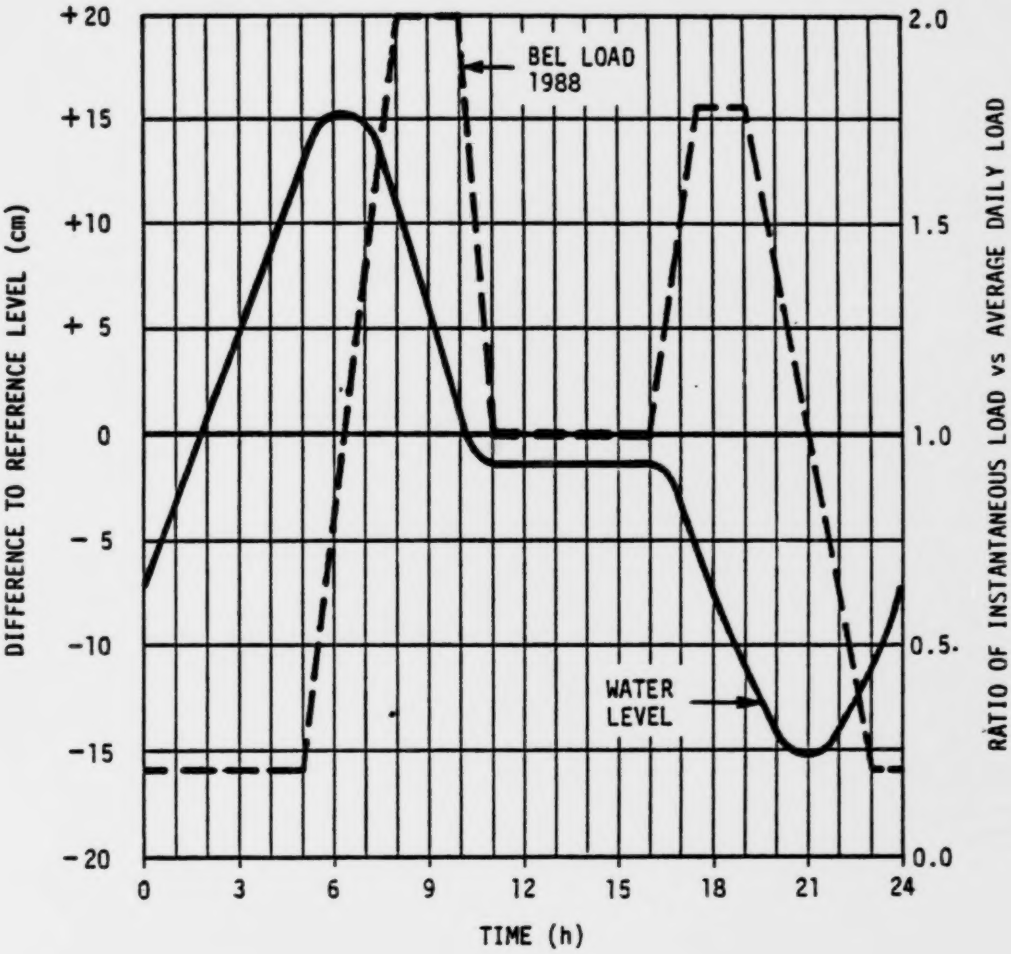
Level D (40.5 m) and Level F (40.0 m) are adjusted during the optimization of the water management to balance two conflicting objectives:

Low Levels for D & F:	This gives a large storage volume with smooth water management, longer periods of high load demand and sufficient time for the operators to adjust the loads to match the energy available from the river inflows.



TYPICAL DAILY LOAD CURVE

FIGURE 4.1

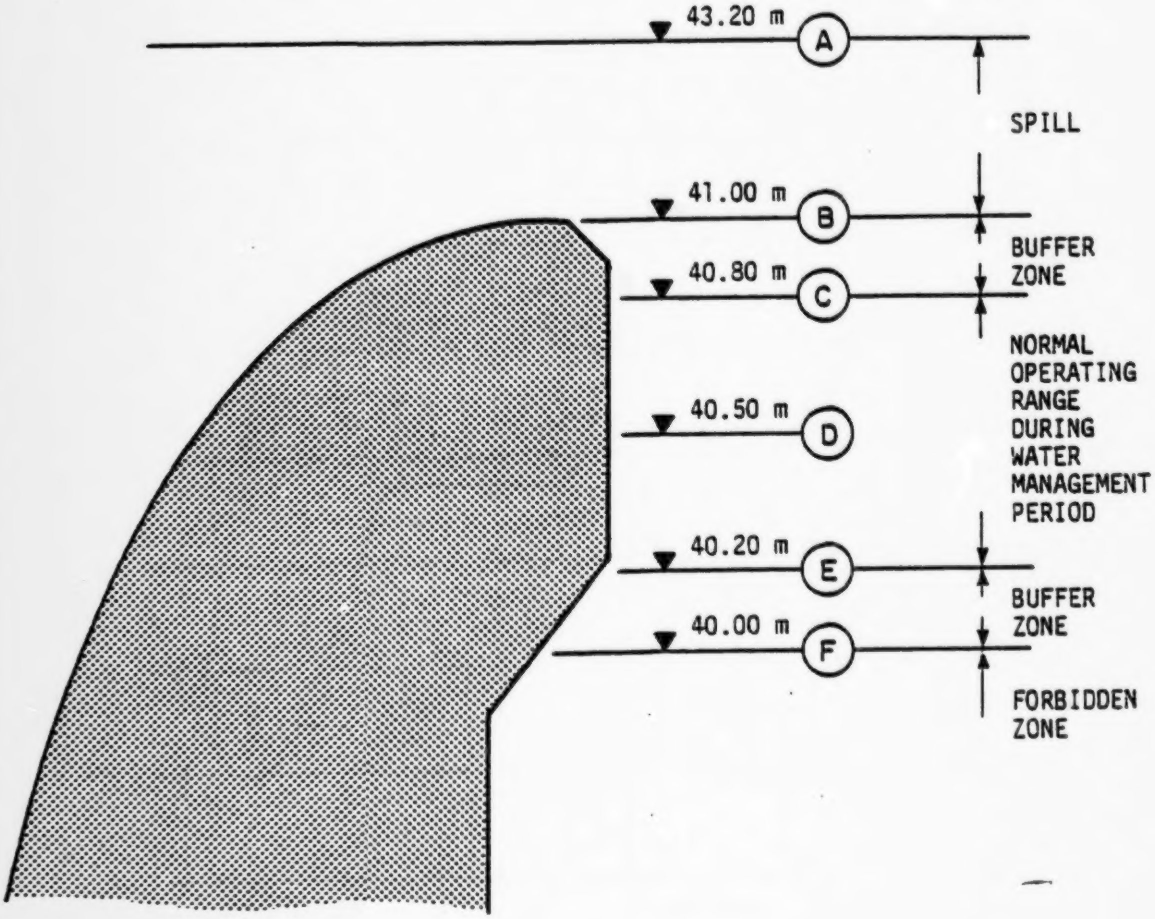


NOTE: THE BEL LOAD CURVE IS BASED ON AN AVERAGE DAILY LOAD OF 250 kW.

THE REFERENCE WATER LEVEL IS REPRESENTED BY THE ZERO VALUE.

DAILY RESERVOIR LEVEL FLUCTUATIONS INDUCED BY LOAD VARIATION

FIGURE 4.2


43.20 m
A
SPILL
41.00 m
B
BUFFER ZONE
40.80 m
C
NORMAL OPERATING RANGE DURING WATER MANAGEMENT PERIOD
40.50 m
D
40.20 m
E
BUFFER ZONE
40.00 m
F
FORBIDDEN ZONE

OPERATING WATER LEVELS

FIGURE 4.3

High Levels for D & F: The efficiency of the mini-hydro is increased because of the higher turbined head. Thus the maximum energy is obtained from the river inflows.

4.3 Diesel Generation

The energy supplied by the diesel generation is shown in Table 4.4 (data suplied by DIAND). The increased energy demand in the winter months is evidence of the use of electricity for SHL because the BEL is assumed to be practically constant throughout the year.

Typical diesel power and generation curves are illustrated in Figures 4.4 and 4.5 respectively (data supplied by DIAND) which show the maximum, minimum and average load demands for the community. (Note: the loads are measured only during "working hours" from 6.00 a.m. to 8.00 p.m. The actual minimum loads may be somewhat lower).

The installation comprises three diesel generators, two rated at 375 kVA each, and one trailer mounted unit rated at 1063 kVA. It is proposed that the trailer mounted unit will be transferrred to the mini-hydro site in May, 1985, and will be connected to the step-up transformers via temporary wiring until the new diesel generator is installed in the generator building.

4.3.1 Initial Operation

Until the summer of 1985, the diesel generators will remain at their present location, remote from the mini-hydro. The synchronizing circuits that are used to switch in diesel units are not sufficiently accurate to permit switching in the diesel generator to an already operating mini-hydro generator. However, the mini-hydro can be synchronized to the diesel generators. Therefore, if parallel operation of the mini-hydro and the diesel generators is required, the diesel generators must be connected first. (Note: This difficulty will be removed when the diesel is transferred to the mini-hydro site because a more accurate synchronizing check circuit will be included in the control facilities).

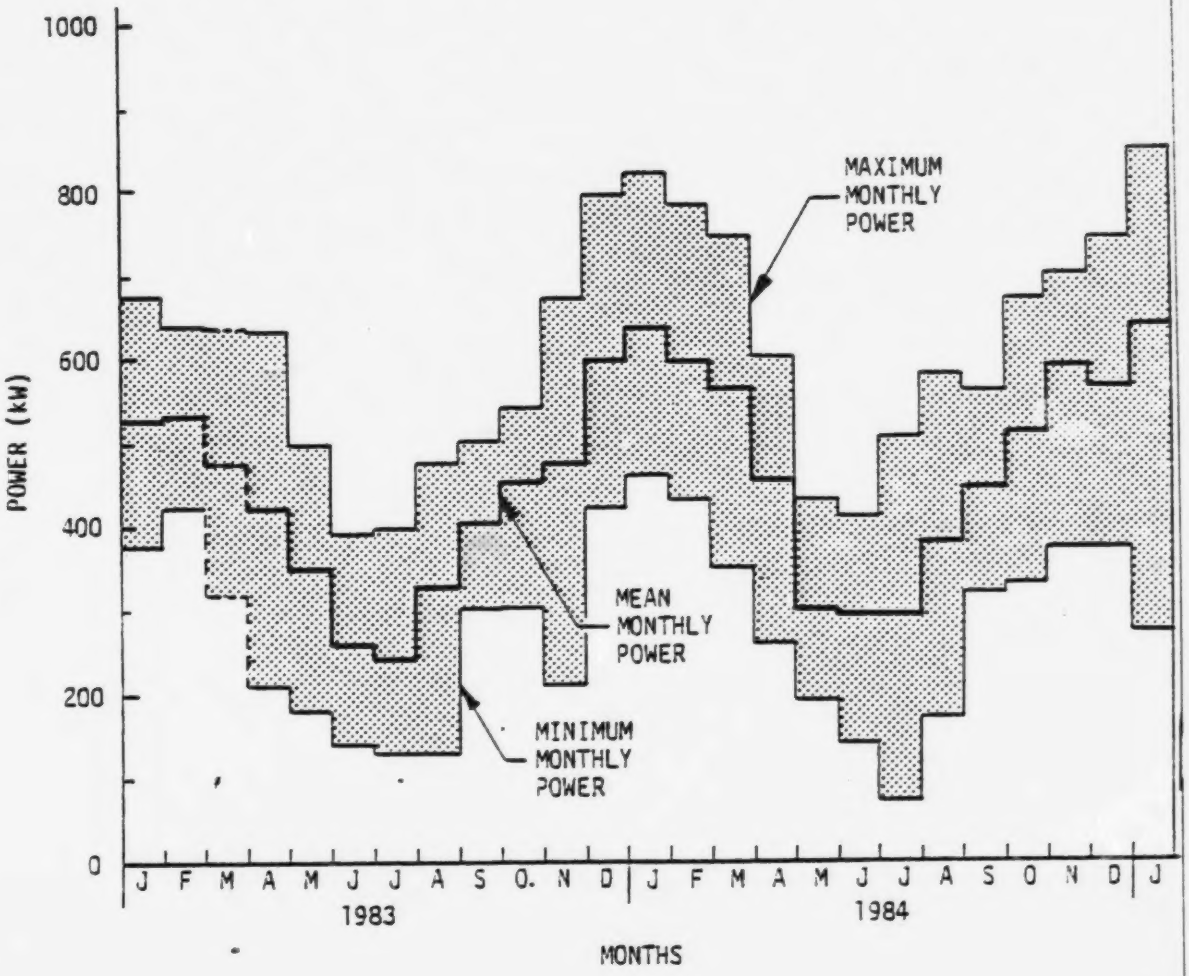
Therefore, it is recommended that for the first few months of 1985 the diesel generator should be permanently connected to the system, to meet the difference between the mini-hydro capacity and the total system load.

The alternative will be to run the mini-hydro alone. When diesel generation is required, the system will be shut down, the diesel started and the mini-hydro synchronized to the system. During the summer and fall months the mini-hydro can supply the great

TABLE 4.4

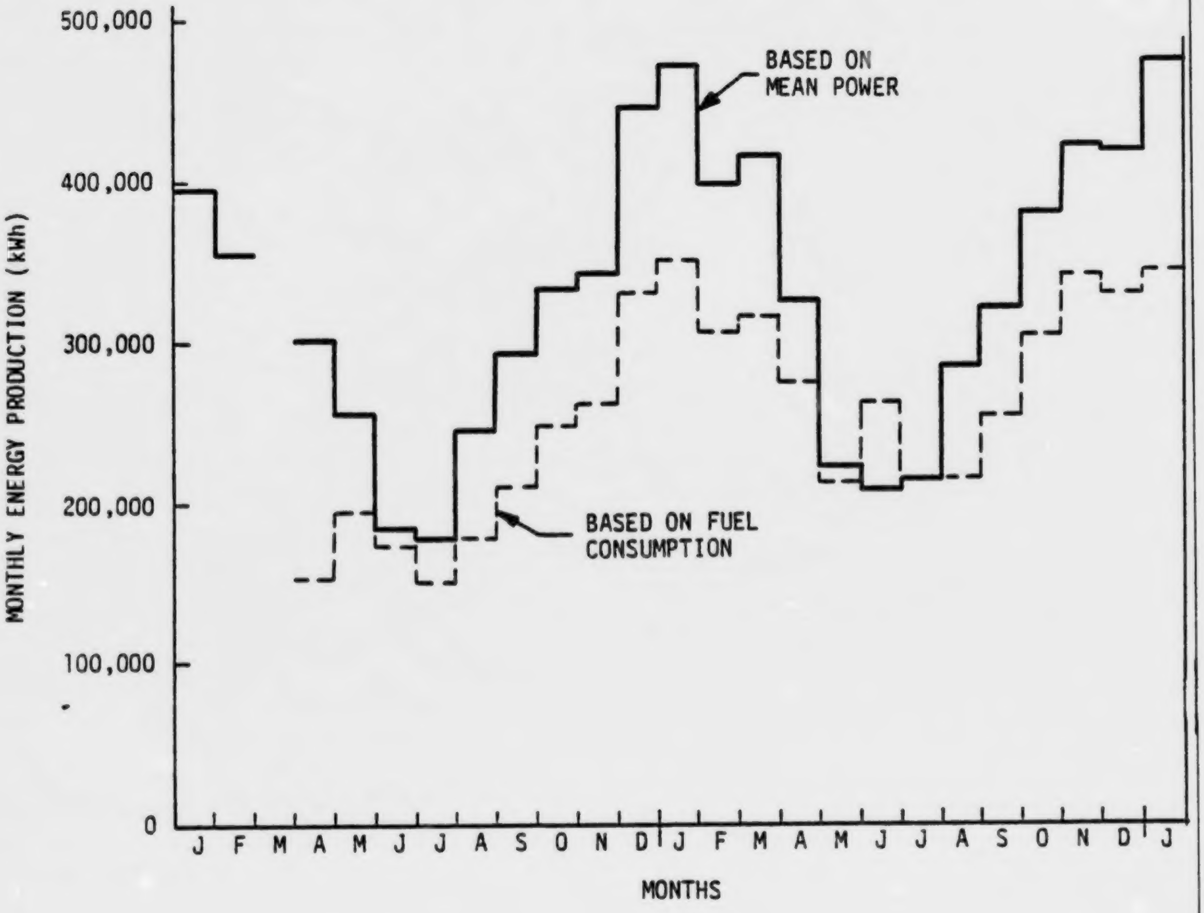
ELECTRIC ENERGY SUPPLIED FROM DIESEL GENERATORS

	POWER (kW)			ENERGY PRODUCTION (kWh)	
MONTH	MAXIMUM	MINIMUM	MEAN	BASED ON FUEL CONSUMPTION	BASED ON MEAN POWER
JAN 83	675	380	527	-	392 100
FEB 83	640	420	530	-	356 200
MAR 83	-	-	-	-	-
APR 83	630	210	420	154 500	302 400
MAY 83	495	180	347	195 600	258 200
JUNE 83	390	140	255	173 100	183 600
JULY 83	400	130	240	150 600	178 600
AUG 83	475	130	328	178 800	244 000
SEP 83	500	300	401	209 100	288 700
OCT 83	540	300	447	246 900	332 600
NOV 83	670	210	471	263 100	339 100
DEC 83	790	420	596	332 700	443 400
JAN 84	820	460	634	350 400	471 700
FEB 84	780	430	590	309 000	396 500
MAR 84	740	350	560	317 700	416 600
APR 84	600	260	452	274 500	325 400
MAY 84	430	190	297	213 300	221 000
JUNE 84	410	140	289	263 100	208 100
JULY 84	505	70	288	214 350	214 300
AUG 84	580	170	380	215 550	282 700
SEP 84	560	320	444	255 600	319 700
OCT 84	670	330	512	306 000	380 900
NOV 84	700	370	588	341 800	423 400
DEC 84	740	370	564	330 900	419 600
JAN 85	850	270	640	343 200	476 200



MONTHLY DIESEL POWER CURVES

FIGURE 4.4



MONTHLY DIESEL GENERATION CURVES

FIGURE 4.5

majority of the community load so the diesel will not be required frequently. This will reduce the overall fuel consumption and the operating and maintenance costs of the diesel units.

The diesel operation during the initial period is discussed further in Section 6.5.1.

4.3.2 Long Term Operation

With proper energy management there should be no need to operate the diesel generators, except during maintenance of the mini-hydro because the mini-hydro capacity is sufficient to supply the BEL. This assumes that the SHL is only supplied by the mini-hydro when sufficient capacity is available and that the community switches from electricity to wood or oil if there is not sufficient capacity or if the total load exceeds 1 100 kW.

The long-term parallel operation of the diesel generator and the mini-hydro is discussed further in Section 6.5.3.

4.4 Firewood for SHL

The "Firewood Report" (Ref. 2) examined the feasibility and costs of supplying the total SHL by a centralized system of harvesting wood. The report indicated that there would be sufficient firewood available for a thirty year planning period, with natural re-forestation only, and with a harvesting radius of up to 20-km.

A summary of the conclusions from the report that are relevant to the EMS study are given in Table 4.5.

The report proposed that dual energy (Wood/Oil) furnaces be installed in all new homes, with wood as the primary fuel and oil as a back-up only. The harvesting would be labour intensive, rather than machine intensive, to create maximum employment and to minimize the outflow of capital from the community.

From the viewpoint of the Energy management System, the significance of the Firewood Study is that a proven source of low cost, renewable energy for SHL has been demonstrated for Wemindji.

TABLE 4.5

CAPACITY AND COSTS OF FIREWOOD
(From Ref. 2)

Type of wood:	Black Spruce
Energy Content: Wet (30%)	4 350 kWh/cord (1)
Dry (20%)	4 982 kWh/cord
Costs per Cord:	$105 to $125/cord
Cost per kWh:	$0.032 to $0.039/kWh (2)
Annual Firewood Demand: (1985)	883 cords
(2013)	1 361 cords
Annual Yield:	2 761 cords
Radius of Harvesting:	Up to 20 km

Note (1) Assumes a full cord of 8ft by 4ft by 4ft

(2) Assumes dry wood and furnaces with 65% efficiency

5.0 ENERGY MANAGEMENT SYSTEMS

5.1 Introduction

The mini-hydro operating conditions (low river inflow in winter and maximum output of 1 100 kW) require a method of controlling the generation and the loads at Wemindji. As a result an Energy Management System (EMS) is required:

- To ensure that there is sufficient mini-hydro capacity to meet the projected BEL demand for the next operating period
- To maximize the use of available mini-hydro energy and to avoid, where possible, the spilling of water
- To minimize the use of diesel generation
- To displace the use of oil heating as much as possible
- To ensure fair distribution of the "low-cost" mini-hydro heating energy within the community

The principle functions of the EMS would be those of forecasting and control.

5.2 Forecasting

It will be necessary to forecast the mini-hydro energy available and the community load demand for the next operating period (24-hours, several days or a month; depending on time of year).

5.2.1 Mini-Hydro Capacity

The energy produced by the mini-hydro during the previous 24-hours and the change in reservoir level will be used to determine the volume of water turbined and the river inflow (Q).

If the reservoir level has decreased during the past 24-hour period, then the energy output from the mini-hydro for the next 24-hour period must be reduced.

If the water level has increased during the past 24-hour period and the power output was less than 1 100 kW, then the mini-hydro energy output can be increased in the next 24-hour period.

This is discussed in greater detail in Section 6.4.1.

5.2.2 Energy Demand

The BEL is assumed to be independent of season and can therefore be found by recording the total electrical load in the summer months when the electric heating are at a minimum. The values obtained can then be used to update and correct the forecast BEL figures each year.

The electric space heating for the past 24-hour period is determined by subtracting the BEL from the total electric load. The SHL for the next 24-hours is projected from the forecast temperature.

This is discussed futher in Section 6.4.2.

5.3 Load Management

Using the predicted values for the mini-hydro capacity (EMH) and for the community electrical load the following operating rules can be applied:

- E_{MH} is greater than (BEL+SHL): Electric heating will be supplied
- E_{MH} is greater than BEL but less than (BEL + SHL) : Limited electric heating willbe supplied
- E_{MH} is less than (BEL) : No electric heating will be supplied

At the generating station there is no way of distinguishing between electricity used for BEL and electricity used for SHL. Some means must be found to control electrical heating at the consumer location (domestic, commercial or institutional).

A number of management options are available:

- No restriction in electricity consumption
- Domestic electrical heating in the summer and fall months only
- Voluntary switching of electric space heating
- Dual tariff electricity metering
- Automatic switching of electric space heating

5.3.1 No Restriction in Electricity Consumption

If there is no restriction on the use of electricity, the limiting factors will be the peak output power and the energy available from the mini-hydro.

If the electrical load demand exceeds 1 100 kW (the rating of the mini-hydro generator) or 1 950 kW (mini-hydro plus diesel) then a "brown-out" will occur. The voltage will be reduced and, if the load continues to increase, the frequency will reduce to the point where the protection will trip the generator and the electricity supply to the community will cease and a complete "black-out" will occur.

If the energy supplied from the mini-hydro exceeds the river inflow, the water level will reduce to the point where the generator has to be disconnected to avoid emptying the reservoir. Electricity will be supplied by the diesel generator until the reservoir has reached an acceptable operating level again.

If the diesel generator is operated in parallel with the mini-hydro the energy daily capacity would be increased by 20 400 kWh (850 kW times 24 hr). However the generation costs for diesel generation have been assessed at 35¢/kWh compared with 9.6¢/kWh for oil heating and 3.2¢/kWh for wood heating. Also, the maximum electrical heating load for the community will exceed the combined mini-hydro/diesel capacity even in 1985 if all members of the community used electrical heating.

The costs to the community for unrestricted electrical consumption would be very high. Without some form of energy management this condition would result.

5.3.2 Domestic Electric Heating in the Summer and Fall Only

The mini-hydro can supply the total load from June through September for the first 30-years of operation. Therefore, in the early years of operation one method of energy management would be to permit electric space heating during the summer and fall months only.

Each domestic consumer would be responsible for switching to non-electric heating during the winter and spring.The operators would monitor and predict the energy demand for the coming year and would advise which months electric space heating would be permitted.

The benefit of this method of energy management is that no special control systems are required and a single tariff could be used for all electrical consumption. This would result in valuable excess energy potential at the mini-hydro being wasted during the winter months.

5.3.3 Voluntary Control of Electric Heating Year-Round

With this system the electrical consumers would switch to non-electric space heating when the mini-hydro capability could not supply the total electrical load.

A number of options are possible for voluntary switching of electric heating:

All-on/all-off control	The whole community would be advised to switch from electric heating to wood or oil heating and vice versa, possibly with little advance notice. This is only possible when the total load (BEL + SHL) is lower than the mini-hydro capacity (1100 kW).
District Control	The village would be subdivided into a number of districts. When necessary, one or more districts would switch to non-electric heating on a rotating basis to share the electric heating benefits equally.
Period Control	The operators would decide how many homes could be electrically heated in a certain month. The consumers would be advised at the beginning of the month of the allowance for that month so that they could make appropriate arrangements.

The communication requirements differ for each of the options. For all-on/all-off or district control, frequent communication would be required and this could be by house to house visits, by telephone, by radio, by closed circuit T.V. or by electronic notice boards posted at strategic areas in the village. For the period control, notices could be delivered or posted each month.

The advantge of voluntary control is that no special equipment is required. The control could be applied if the peak load demand exceeds 1 100 kW or if the reservoir level is low. Also, a single tariff is possible for electricity.

The disadvantage is the need to communicate frequently with each consumer.

5.3.4 Dual Tariff Electricity Metering

With dual tariff metering, a lower rate per kWh would be charged for the BEL electricity and a higher rate for SHL, depending on the mini-hydro capacity (Different types of electricity meters are discussed in Appendix E).

The rate structure would be decided by the management committee. One option would be to suply the BEL without charge, or at a nominal rate to cover only the operating costs of the mini-hydro. The first block of kWh for BEL would be charged at the low rate. Depending on the mini-hydro capacity, the second block of kWh would be at a higher rate to discourage overconsumption, but at lower cost than oil heating. The final block of kWh would be charged at a rate equivalent to the diesel generation rate.

The operators would forecast the average electrical capacity of the mini-hydro as a function of season. They would then allocate to each consumer a block of kWh for the BEL. The remaining capacity for space heating would be divided between consumers according to an overall plan decided by the management committee.

At the beginning of each operating period the consumers would be informed of their allocation of low cost BEL electricity and the higher costs for electrical consumption above this level. The electricity meter would be read at the beginning and at the end of each period.

The benefit of dual tariff metering is that any consumer may choose the convenience of electric heating, as opposed to lower cost wood heating, provided they can pay the increased costs.

The main disadvantage of dual tariff metering is that all meters must be read at frequent intervals so that the demand tariffs can be matched to the mini-hydro capacity. A second problem may arise if the domestic consumers are unaware of the financial burden that arises from electric heating at the highest tariff.

5.3.5 Automatic Switching of Electric Heating

If automatic control of space heating is used, two requirements must be satisfied:

- The electric heating at each consumer must be on a separate circuit from the BEL

- There must be an alternative heating source which takes over automatically when the electric heating is disconnected.

The control signals will be generated from the powerhouse and transmitted to each consumer, via the electricity distribution system or via the telephone circuits. The controller and transmitter would be located at the powerhouse or elsewhere in the village, for example at the Band Office. Receivers would be located at each distribution transformer or at each building, with direct wiring to each consumer control switch. It would be possible to control individual consumers or groups of consumers depending on the degree of sophistication required.

In its simplest form, the control would be one-way (that is the powerhouse controlling the electrical heating) but it is possible to have two way signalling with remote meter reading, temperature monitoring of individual homes, etc.(The controller is described in Appendix E).

The decision to switch electric heating in and out could be made manually, or automatically by a simple computer monitoring program.

With manual operation, the operator would determine the mini-hydro capability and the load demand and would calculate the number of consumers to be switched to non-electric heating. He would then feed the information to the control unit which would disconnect and reconnect groups of consumers as required. This switching would be on a rotating basis so that the benefits of electric heating would be shared between the consumers.

With automatic operation, the computer would be programmed with the mini-hydro capability and the load forecast. It would monitor the actual load and energy demand and would generate the appropriate signals to switch electric heating in and out on a rotating basis.

The benefits of automatic switching are that communication with consumers and frequent meter readings are avoided. Also, the control can be adjusted to maximize the use of the mini-hydro energy, maintain capacity to meet the BEL and keep the peak load to 1 100 kW, or any other required value.

The main drawback of the system is the initial cost. Also, it cannot control "unauthorized" electric space heating, by 110 V baseboard heaters or by opening the oven door.

5.4 Equipment

The main components that would be installed in the Wemindji EMS will depend on the method chosen and the degree of sophistication required.

Electricity Meters

At present, the majority of consumers do not pay for electricity and there are no meters installed. One meter would be required for each home in the community and two options are available:

If single tariff metering is chosen, a conventional electromechanical meter may be installed, as has been in use for many years. This meter would be read by the operators at the end of each billing period. A typical meter is shown in Appendix E.

If dual tariff metering is chosen, a "programmable" meter would be required (see Appendix E). This would have variable tariff setting and may also have such features as automatic reading facilities or remote reading capability.

Electric Heaters

Electric heating in the new model homes could be by electric plenum heaters installed in the forced air heating system in parallel with the wood/oil furnace, or by baseboard heaters in each room, fitted with individual thermostats (typical units are shown in Appendix E).

In the older homes, which are planned to be replaced within 5-years, it is proposed that portable heaters will be used. It would be necessary to have several heaters in each home.

Automatic Controls

A typical automatic control system is illustrated in Appendix E. It would include control and transmitter equipment located at the central control centre, or elsewhere in the village and remote receivers/switches at each electric load. The control would be at the 220 V level so that the BEL in each home would not be affected. It is assumed that the switching would be installed only in the new model homes that have dual energy heating systems.

6.0 PROPOSED ENERGY MANAGEMENT SYSTEM FOR WEMINDJI

6.1 Introduction

An energy management system must be able to:

- Forecast energy availability from various sources
- Forecast energy demands for various needs
- Establish exploitation rules for the available energy sources
- Control the use and consumption of energy.

During a meeting held at Wemindji on January 24, 1985 it was decided that the control of electric heating would be carried out by district control on a voluntary basis. The system is described in detail in Section 6.2.

The exploitation rules for each of the energy resources are described in Section 6.3 and the methodology for forecasting the demand and supply is described in Section 6.4.

In Section 6.5 the operating procedures for the initial period (April to June 1985), the first year of normal operation (July 1985 to June 1986) and the long term operation are described.

6.2 Description of Control System

The method by which the use of energy will be controlled is by voluntary district control. The reasons for selecting voluntary district control are the following:

- It avoids the need to install, operate and maintain complex automatic switching and monitoring systems.
- It allows the people using the energy resources to better understand how they work and what their limitations are.
- It will improve community spirit and participation, in general, by including them in the decision process.

At this time it is proposed that the community be subdivided into eight districts, each district representing an equal energy demand. The districts would be designated as seven community districts and one third party user district (refer to Appendix C for list of third party users). The number of houses and buildings in each of the eight heating districts will depend on the load demands, their location and their relative position with respect to the distribution grid. The number of heating districts would be optimized after a certain number of months of operation.

Each district would have two representatives who would be responsible for communication between the district and the operators in charge of the energy management system. These representatives would be informed of whether their district may use electric heating and it would then be their responsibility to inform the members in their districts.

For the third party users, it is suggested that the electricity consumption be monitored and charged to the consumers at a fair rate (to be decided), thereby enabling the recovery of a portion of the capital investment in the mini-hydro corresponding to the percentage of third party electricity usage.

The eight districts would only be allowed to heat with electricity when energy is in excess of the BEL available.

The operator would decide on how many districts could be supplied with electric heating, on a daily or weekly basis, and he would inform the district representatives as to which districts may use electric heating and for how long a period. This would be done in a fair manner so as to distribute the available resource equally to all community members. One method by which this could be done is to rotate the districts on a weekly basis (see Table 6.1 for an example).

6.3 Energy Resource Management

There are four basic sources of energy for the Wemindji community. These sources are:

- Mini Hydro
- Diesel
- Wood
- Heating Oil

The recommended management procedure for each of these resources is detailed in the following section.

6.3.1 Mini-Hydro

In the months of May through December there will be, on average, sufficient river inflow to operate the mini-hydro at its maximum rated output of 1 100 kW. Therefore, mini-hydro water management is not necessary as there will be water spillage.

TABLE 6.1

TYPICAL DISTRIBUTION OF ELECTRIC HEATING

PERIOD / DISTRICT #	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL HEATED PERIODS PER DISTRICT
1	x	x		x			x	x	x	x	x		8
2	x	x			x		x	x	x	x	x		8
3	x		x		x		x	x	x	x	x		8
4	x		x		x		x	x	x	x		x	8
5	x		x			x	x	x	x	x		x	8
6		x	x			x	x	x		x	x	x	8
7		x		x		x		x	x	x	x	x	8
8		x		x		x		x	x	x	x	X	8
# OF HEATED DISTRICTS	5	5	4	3	3	4	6	8	7	8	6	5	

Note: (1) In this example a period is 1 week.

(2) Total number of heating districts is assumed to be eight.

In the winter months, when the inflow to the powerhouse is less than the plant capacity and total energy and load demand exceeds the mini-hydro capacity, water management becomes essential.

The typical water and energy management procedure is outlined below, and explained in more detail in Section 6.4.

The amount of energy available from the mini-hydro, for the coming period, is determined by calculating the mini-hydro energy production for the previous period (see Section 6.4.1) assuming that the inflows will not vary greatly from one period to the next.

The forecasted total community energy demand is calculated (see Section 6.4.2) and the number of heating districts which can be supplied by electric energy is determined (see Section 6.4.3).

The mini-hydro will then be operated, during the coming period, in such a way as to meet the total demand, allowing the reservoir to fluctuate between the minimum and maximum operating levels as described in Section 4.2.2. If the load demand exceeds the mini-hydro capacity then the diesel generators will be operated in parallel with the mini-hydro in order to meet the peak loads.

6.3.2 Diesel

The diesel generators will be managed in such a way as to ensure that they are used only if the mini-hydro capacity is insufficient to meet the peak BEL demand or in case of temporary outage of the mini-hydro. After the operating procedures are well established and properly used by the operators and understood by the community, diesel energy should no longer be used for heating.

6.3.3 Wood

It is recommended that wood harvesting be developed by the community so that all community members can benefit equally from the available resources.

This would create employment during the winter months, when employment level is lower than usual, as the harvest would be carried out only during these months in order to facilitate transportation.

A fair price should be charged for this resource presently estimated at $105/cord. This represents an average energy cost for heating of 2.0 ¢/kWh. The benefit of using this resource is that the money would remain within the community and therefore assist in its growth. In addition to this, this resource is renewable and therefore has intrinsic benefits.

6.3.4 Heating Oil

The cost of oil heating has been estimated as 9.6¢/kWh which is five times the cost of heating by wood. Therefore, efforts should be undertaken to convince the community members to exploit the cheaper renewable resources (mini-hydro and wood) available to them.

It should also be pointed out that most of the cost for heating oil would not remain within the community and that its availability and price are uncontrollable negative factors.

6.4 Forecasting

This section will describe in detail the methodology used to forecast the availability of mini-hydro energy, the demand for basic electric energy and heating energy and the amount of hydroelectric energy available for heating.

6.4.1 Mini-hydro Capacity

The mini-hydro energy capacity for two consecutive days will normally be the same because the river inflows will be approximately equal. The energy capacity is determined as follows:

Water Turbined:

The energy output from the mini-hydro for the past 24-hours is found by subtracting the Energy Meter Reading (kWh) for a particular time "yesterday" from the reading for the same time "today". Then the turbined water is determined by multiplying the energy output by a factor of 2 000 to give the water flow in m^3/s, and by 86 400 to give the total volume of turbined water in 24 hours.

Reservoir Storage:

The volume of water has been calculated for different reservoir levels and is tabulated in Table 6.2 (Note: This table corresponds to Table 1 refered to in Figure 6.1). By determining the difference in reservoir storage between yesterday and today the net reduction/increase in reservoir storage volume is found.

River Inflow:

The river inflow is determined by subtracting or adding the change in reservoir storage to the total volume of water turbined. If there has been a net decrease in reservoir storage during the previous period, then the river inflow is equal to the total turbined water minus the decrease in reservoir storage. If there has been a net increase in reservoir storage during the

TABLE 6.2

RESERVOIR LEVEL VERSUS STORAGE

LEVEL (m)	STORAGE x 10^{-3} (m^3)
40.00	690
40.05	701
40.10	711
40.15	721
40.20	732
40.25	742
40.30	753
40.35	763
40.40	774
40.45	785
40.50	796
40.55	807
40.60	818
40.65	829
40.70	840
40.75	851
40.80	862
40.85	874
40.90	885
40.95	897

LEVEL (m)	STORAGE x 10^{-3} (m^3)
41.00	908
41.05	920
41.10	932
41.15	944
41.20	956
41.25	968
41.30	980
41.35	992
41.40	1004
41.45	1017
41.50	1029
41.55	1041
41.60	1054
41.65	1067
41.70	1079
41.75	1092
41.80	1105
41.85	1118
41.90	1131
41.95	1144

LEVEL (m)	STORAGE x 10^{-3} (m^3)
42.00	1157
42.05	1170
42.10	1184
42.15	1197
42.20	1211
42.25	1224
42.30	1238
42.35	1252
42.40	1265
42.45	1279
42.50	1293
42.55	1307
42.60	1321
42.65	1335
42.70	1350
42.75	1364
42.80	1378
42.85	1393
42.90	1408
42.95	1422

previous period, then the river inflow is equal to the total turbined water plus the increase in reservoir storage.

Figure 6.1 illustrates a typical form that will be used by the operator, in conjunction with Table 6.2 to determine the amont of hydroelectric energy available for the coming period.

6.4.2 Energy Demand

The BEL for each year will be determined by measuring the electrical load in the preceeding summer months, when the SHL is at a minimum. The BEL will be assumed to be constant throughout the year. Forecasted values are listed in Table 6.3.

The SHL will vary with the outside temperature. Therefore, the average forecast temperature for the next 24-hours will be used to determine the SHL as follows:

$$SHL_n = (18.0 - T_n) \times F_y$$

where SHL_n is the space heating demand for the next 24 hour period

T_n is the forecast average temperature for the next 24 hour period

18.0 is assumed to be the average inside temperature for the next 24 hour period in °C and

F_y is the space heating factor for year y (obtained from Table 6.4).

Figure 6.2 illustrates a typical form that will be used by the operator to determine the BEL, SHL and total demand. Tables 6.3 and 6.4 will be used by the operator to determine values for BEL and SHL factor for each period (Note: These tables correspond to Tables #2 and 3 refered to in Figure 6.2).

6.4.3 Heating supplied by Mini-Hydro

Having forecasted the amount of energy available from the mini-hydro for the coming period and the community BEL and SHL demands, the next step is to determine the number of heating districts that can be supplied with hydroelectric energy for heating, the method by which this is done is the following:

- Determine the total amount of hydroelectric energy available (refer to Section 6.4.1).

DATE	M	D	Y 19	DAY	S M T W T F S	OPERATOR	

I AVAILABLE MINI-HYDRO ENERGY

(1) ENERGY METER READING AT 9:00 A.M. TODAY ____ kWh

(2) ENERGY METER READING AT 9:00 A.M. YESTERDAY ____ kWh

(3) ENERGY PRODUCED YESTERDAY
(Subtract line (2) from line (1))
(1) ____ − (2) ____ = ____ kWh

(4) AVERAGE TURBINE FLOW
(Divide line (3) by 2000)
(3) ____ ÷ 2000 = ____ m^3/s

(5) WATER LEVEL READING AT 9:00 A.M. TODAY ____ m
(If water level reading is greater than 41.00 m, then write 41.00 m) → ____ m

(6) RESERVOIR VOLUME AT 9:00 A.M. TODAY ____ $x10^3\ m^3$
(Use value from line (5) and TABLE 1)

(7) WATER LEVEL READING AT 9:00 A.M. YESTERDAY ____ m
(If water level reading is greater than 41.00 m, then write 41.00 m) → ____ m

(8) RESERVOIR VOLUME AT 9:00 A.M. YESTERDAY ____ $x10^3\ m^3$
(Use value from line (7) and TABLE 1)

IF LINE (8) IS LESS THAN LINE (6) COMPLETE THIS SECTION

(9) RESERVOIR ACCUMULATION
(Subtract line (8) from line (6)
(6) ____ − (8) ____ = ____ $x10^3\ m^3$

(10) AVAILABLE FLOW FROM CHANGE IN RESERVOIR STORAGE
(Divide line (9) by 86.4)
(9) ____ ÷ 86.4 = ____ m^3/s

(11) TOTAL AVAILABLE FLOW TODAY
(Add line (10) to line (4))
(4) ____ + (10) ____ = ____ m^3/s

(12) TOTAL AVAILABLE ENERGY TODAY
(Multiply line (11) by 2000)
(11) ____ × 2000 = ____ kWh

IF LINE (8) IS GREATER THAN LINE (6) COMPLETE THIS SECTION

(9) RESERVOIR ACCUMULATION
(Subtract line (6) from line (8)
(8) ____ − (6) ____ = ____ $x10^3\ m^3$

(10) AVAILABLE FLOW FROM CHANGE IN RESERVOIR STORAGE
(Divide line (9) by 86.4)
(9) ____ ÷ 86.4 = ____ m^3/s

(11) TOTAL AVAILABLE FLOW TODAY
(Subtract line (10) from line (4))
(4) ____ − (10) ____ = ____ m^3/s

(12) TOTAL AVAILABLE ENERGY TODAY
(Multiply line (11) by 2000)
(11) ____ × 2000 = ____ kWh

DETERMINATION OF AVAILABLE MINI-HYDRO ENERGY

FIGURE 6.1

TABLE 6.3

ESTIMATED BEL

YEAR	DAILY BEL (kWh)
1985	5590
1986	5810
1987	6010
1988	6100
1989	6205
1990	6385
1991	6525
1992	6670
1993	6780
1994	6893
1995	7000
1996	7110
1997	7225
1998	7335
1999	7445
2000	7555
2001	7665
2002	7775
2003	7890
2004	8000
2005	8105
2006	8220
2007	8330
2008	8505
2009	8680
2010	8860
2011	9040
2012	9215
2013	9390
2014	9565
2015	9745
2016	9925
2017	10100
2018	10275
2019	10454
2020	10630
2021	10810
2022	10985
2023	11160
2024	11340
2025	11520
2026	11695
2027	11870
2028	12045
2029	12225
2030	12405
2031	12580
2032	12755
2033	12930
2034	13105
2035	13280

DATE	M	D	Y 1,9	DAY	S	M	T	W	T	F	S	OPERATOR	

2	TOTAL ENERGY DEMAND

(20) BASIC ELECTRIC DEMAND EXPECTED TODAY
(See TABLE 2) ______ kWh

(21) EXPECTED AVERAGE OUTSIDE TEMPERATURE TODAY
(If greater than 18.0, insert 18.0) ___.___ °C

(22) SPACE HEATING FACTOR
(See TABLE 3) ______

(23) SPACE HEATING ENERGY EXPECTED TODAY
(Subtract line (21) from 18.0,
then multiply by line (22).

[18.0 − (21) ______] X (22) ______ = ______ kWh

(24) TOTAL ENERGY DEMAND EXPECTED TODAY
(Add line (20) and line (23))

(20) ______ + (23) ______ = ______ kWh

(25) SUBTRACT LINE (24) FROM LINE (12)

(12) ______ − (24) ______ = ______ kWh

NOTE: Value may be POSITIVE or NEGATIVE, please indicate.

(26) SUBTRACT LINE (20) FROM LINE (12)

(12) ______ − (20) ______ = ______ kWh

NOTE: Value may be POSITIVE or NEGATIVE, please indicate.

(27) TOTAL NUMBER OF HEATING DISTRICTS ______

COMMENTS: ______

DETERMINATION OF TOTAL ENERGY DEMAND

FIGURE 6.2

TABLE 6.4

ESTIMATED SHL FACTOR

YEAR	SHL FACTOR
1985	743
1986	760
1987	827
1988	839
1989	851
1990	877
1991	898
1992	910
1993	930
1994	946
1995	966
1996	999
1997	1002
1998	1034
1999	1053
2000	1070
2001	1090
2002	1124
2003	1145
2004	1166
2005	1187
2006	1208
2007	1229
2008	1251
2009	1274
2010	1296
2011	1318
2012	1340
2013	1363
2014	1385
2015	1407
2016	1429
2017	1451
2018	1465
2019	1480
2020	1494
2021	1508
2022	1523
2023	1553
2024	1583
2025	1613
2026	1643
2027	1673
2028	1695
2029	1717
2030	1739
2031	1762
2032	1784
2033	1807
2034	1830
2035	1853

- Determine the BEL and SHL for the coming peiod (refer to Section 6.4.2).
- Subtract the BEL from available hydroelectric energy.

If this yields a negative value or zero, then the BEL exceeds or meets the available hydroelectric energy. In this case no electric heating is allowed and the diesel generators must be run in order to supply the BEL that cannot be supplied by the mini-hydro.

If this yields a positive value, then electric heating will be supplied. The number of heating districts that will be electrically heated is computed by subtracting the (BEL + SHL) from the available hydroelectric energy.

If the value is greater than zero, all the heating districts will be supplied with electric heating.

If the value is less than zero, then the number of districts provided with electric heating is computed as follows:

$$D_h = \frac{(E_{mh} - BEL) \times D_t}{SHL}.$$

where;	D_h	is the number of heating districts to be provided with electric heating,
	E_{mh}	is the available energy from the mini-hydro for coming period,
	BEL	is the basic electric demand for coming period,
	SHL	is the heating demand for coming period and
	D_t	is the total number of heating districts.

It should be noted that the value of D_h is rounded off to lower integer value (Example: If $D_h = 5.7$ then it is rounded of to 5). The form used by the operator is illustrated in Figure 6.3. This assumes that heating districts will be divided in such a way that their heating loads are more or less equal.

Once the number of heating districts that can be supplied with electric heating is established, the operator is responsible to contact all heating district representatives and inform them as to whether their district can or cannot use electric heating.

DATE	M	D	Y	DAY	S	M	T	W	T	F	S	OPERATOR	

3	HEATING ENERGY MANAGEMENT OPTIONS

SELECT APPROPRIATE OPTION: A ☐ B ☐ C ☐

OPTIONS

DESCRIPTION	NUMBER OF HEATING DISTRICTS SUPPLIED
A SELECT OPTION "A" IF LINE (25) IS POSITIVE OR EQUAL TO ZERO.	ALL DISTRICTS SUPPLIED WITH ELECTRIC HEATING (Insert value from line (27)) ☐
B SELECT OPTION "B" IF LINE (26) IS NEGATIVE OR EQUAL TO ZERO.	NO DISTRICTS SUPPLIED WITH ELECTRIC HEATING 0
C SELECT OPTION "C" IF LINE (26) IS GREATER THAN ZERO AND LINE(25) IS LESS THAN ZERO.	SOME DISTRICTS SUPPLIED WITH ELECTRIC HEATING (Complete section below to compute number of districts supplied with electric heating.) ☐

COMPLETE THIS SECTION IF OPTION "C" IS SELECTED

SUBTRACT LINE (20) FROM LINE (12)

DIVIDE BY LINE (23)

MULTIPLY BY LINE (27)

ROUND-OFF VALUE TO LOWER INTEGER VALUE

EXAMPLE: If value is 5.6, then round-off to 5

$$\left[\frac{\overset{(12)}{\boxed{}} - \overset{(20)}{\boxed{}}}{(23)\,\boxed{}}\right] \times \overset{(27)}{\boxed{}} = \boxed{}$$

ESTABLISHMENT OF HEATING ENERGY MANAGEMENT OPTION

FIGURE 6.3

6.5 Operating Procedures

This section will be used to describe the operation of the Energy Management System. The operation has been subdivided into three periods; the initial period from April to June 1985, the first full year of operation from July 1985 to June 1986 and the long term operation from July 1986 onward.

The methodology to be followed by the operators has been described in detail in Sections 6.3 and 6.4. The following is a brief outline:

- The amount of energy available from the mini-hydro is determined by estimating the total river flow expected for the coming period and calculating its hydroelectric energy value.
- The BEL for the period is obtained by assuming that it is equal to the BEL for the previous summer months, when the heating loads are close to zero.
- The SHL is computed with the forecasted average temperature for the period and the SHL factor, which is based on the number and type of homes and buildings within the community.

  The SHL factor must be updated on a regular basis to keep in step with new home and building development.
- Having established the amount of available hydroelectric energy and the total community energy demand (BEL + SHL) the operators then determine the number of heating districts that can be supplied with electric heating.
- The heating district representatives are informed as to whether or not electric heating will be available for their districts for the coming period.
- The mini-hydro is then operated in such a way as to provide the energy and load demands over the coming period.

6.5.1 Initial Operation (April to June, 1985)

The initial operating conditions will be very different from those described in the previous sections. The reasons for this are the following:

- Until the summer of 1985, the diesel generators must be permanently connected because the diesel generators cannot be synchronized to the min-hydro

- Inexperience with the mini-hydro may result in a number of occasions when the mini-hydro will be shut down and increased diesel generation will be required and

- The altitude of community members towards the use of energy and the need for conservation is not expected to change overnight. Therefore the habit of using electric heating during the winter months is expected to continue.

Because of these reasons, the total electric demand will be much greater than the actual BEL. Even with the mini-hydro operating at its maximum monthly capacity, it will not be able to completely satisfy the electricity demand. Therefore, the diesel generators will continue to be operated in parallel in order to supply the difference between mini-hydro energy production and total electricity demand.

During this period the operators will gain experience in operating the mini-hydro and diesel combinations as well as the energy management system.

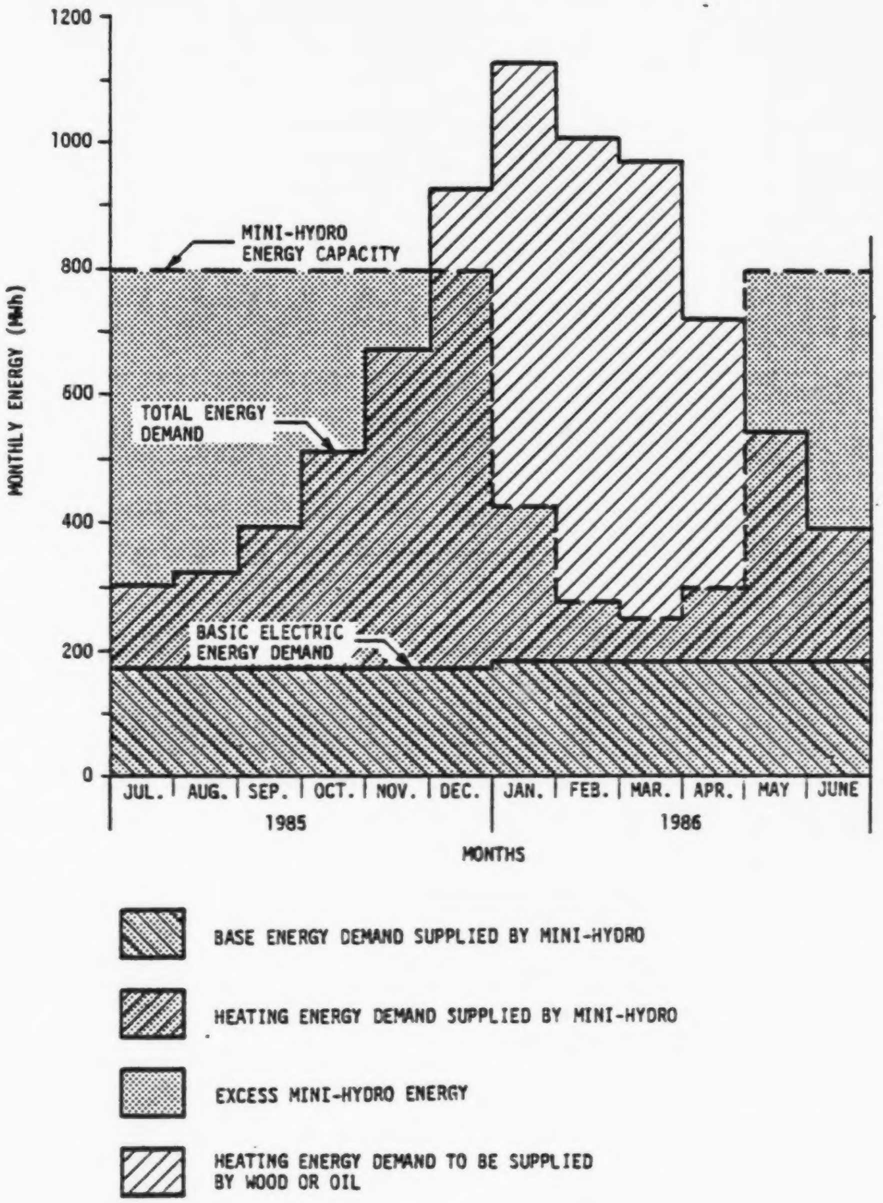
6.5.2 First Year Operation (July 1985 to June 1986)

The problems encountered during the initial period of operation should be overcome by the end of June 1985. The diesel generators will be transferred to the mini-hydro site and synchronization problems will be eliminated. Therefore for the first full year of operation, the operation will follow the methodology described in Sections 6.3 and 6.4.

Using the average monthly energy demand estimates (Reference 3) and the average monthly mini-hydro electric production it has been determined that 100% of the BEL and 66% of the SHL can be supplied by the mini-hydro. Table 6.5 and Figure 6.4 are used to tabulate and illustrate the results on a monthly basis.

In Table 6.5 the energy demand has been separated into two sectors, the community and third party users. From information presently available it seems that the third party users are responsible for 25-30% of the total electricity consumption during the past year. At this time, it has been decided to use a value of 25% as their portion of the energy demand. This value will be reevaluated based on information collected during the first few months of operation.

The heating energy that cannot be supplied by the mini-hydro during this period will be supplied by either wood or heating oil.



FORECAST ENERGY SUPPLY AND DEMAND (JULY 1985 TO JUNE 1986)

FIGURE 6.4

TABLE 6.5

FORECAST ENERGY SUPPLY SCENARIO (JULY 1985 TO JUNE 1986)

MONTH	MINI-HYDRO CAPACITY (Mwh) (1)	FORECAST BEL (Mwh)			FORECAST SHL (Mwh) (2)			TOTAL ENERGY DEMAND (Mwh)	ENERGY SUPPLY (Mwh)		
		RES. (3)	THIRD PARTY (4)	TOTAL	RES. (3)	THIRD PARTY (4)	TOTAL		MINI HYDRO	OTHER SOURCES	ELECTRIC (5) HEATING
JUL 85	800	127.5	42.5	170	97.5	32.5	130	300	300	-	8
AUG 85	800	127.5	42.5	170	112.5	37.5	150	320	320	-	8
SEP 85	800	127.5	42.5	170	165.0	55.0	220	390	390	-	8
OCT 85	800	127.5	42.5	170	255.0	85.0	340	510	510	-	8
NOV 85	800	127.5	42.5	170	375.0	125.0	500	670	670	-	8
DEC 85	800	127.5	42.5	170	566.0	189.0	755	925	800	125	7
JAN 86	430	135.0	45.0	180	712.5	237.5	950	1130	430	700	3
FEB 86	280	135.0	45.0	180	622.5	207.5	830	1010	280	730	2
MAR 86	250	135.0	45.0	180	592.5	197.5	790	970	250	720	2
APR 86	300	135.0	45.0	180	405.0	135.0	540	720	300	420	4
MAY 86	800	135.0	45.0	180	270.0	90.0	360	540	540	-	8
JUN 86	800	135.0	45.0	180	157.5	52.5	210	390	390	-	8
TOTAL	7660	1575	525	2100	4331	1444	5775	7875	5180	2695	-

Note:
(1) Mini-hydro capacity based on average inflows in the river
(2) Forecast SHL is based on average monthly temperatures
(3) RES. is the community portion of the energy demand
(4) THIRD PARTY is the portion of the energy demand for third party usage
(5) Electric heating refers to the number of heating districts supplied with electricity (total number of heating districts is eight)

If the remaining heating needs are supplied 100% by wood, this would mean that the community must stock approximately 840 cords of wood at a total cost of $87,350. If on the other hand the remaining heating demand is supplied by heating oil, it would require approximately 360,000 litres of fuel at a cost of $258,700.

The frequency of the mini-hydro being out of operation as a result of a breakdown or for maintenance has been estimated to be 5%. Therefore enough diesel oil should be stocked in order to supply diesel electricity during periods when the mini-hydro is inoperative for whatever reasons. It is estimated that 90,000 litres of diesel fuel will be required (as backup) at a cost of $40,500.

6.5.3 Long Term Operation

The long term operation will be similar to the operation described in Section 6.5.2, except that the values will change from year to year and month to month.

The long term operation will also be modified, so that information gathered during the first and subsequent years of operation can be reflected in the operating rules. This will result in further optimization, or fine tuning, of the energy management system.

7.0 COST ESTIMATES

The estimated total cost of converting all residences to dual heating, electric and oil or wood, varies depending on the heating devices installed. If baseboard heaters are used for all residences, then the total cost will be $115,000 including installation. If on the other hand the new homes are installed with plenum heaters, then the total cost will be $123,000.

The approximate cost of equiping the community with electricity meters is estimated at $30,000 for single tarif meters and $55,000 for dual tarif meters.

An automatic control system for the community would cost approximately $117,000 for the master control unit and the local control receivers (not including installation).

It should be pointed out that these are the costs for converting only the 144 homes. These homes are classified as 30 new homes, 107 attached and "old" homes and 8 trailers (Estimates obtained from Reference 3).

The unit equipment cost is detailed below.

7.1 Electric Plenum Heaters

Equipment of the type shown in Appendix E is readily available from Canadian suppliers. The following prices are typical:

Plenum Heater (up to 15 kW capacity)	$ 650
Feeder Cable (40 ft; 2 conductors #2)	$ 100
Fused Switch	$ 100
Installation (including load limiter)	$ 700
Total Cost per Unit	$1550

7.2 Baseboard Heaters

Electric heating could be by baseboard heaters located in each room. Typical cost for equipment are:

Baseboard Heaters (up to 1.5 kW)	$ 80
Installation	$ 50
Total Cost per Unit	$ 130

7.3 Electricity Meters

Two types of meters have been considered, single tariff and dual tariff. Typical costs of Canadian equipment, shown in Appendix E, are:

- Single Tariff Meter : $ 60
  Installation : $ 150

  Total Cost per Unit : $ 210

- Dual Tariff Meter : $ 180
  Installation : $ 200

  Total Cost per Unit : $ 380

7.4 Automatic Control System

A typical control system is described in Appendix E. Typical equipment costs (without installation) would be:

Master Control and Transmitter Units : $100 000
Load Control Receivers (One per consumer): $ 120

8.0 CONCLUSIONS AND RECOMMENDATIONS

Different forecasts for the energy demand at Wemindji were reviewed and compared with the capacity of the Maquatua mini-hydro installation. It was demonstrated that there will be sufficient capacity to supply the Basic Electric Load and all, or part, of the Space Heating Load throughout the year for a number of years in the future.

A number of EMS options were reviewed and discussed with the community. At a general meeting is was decided that a voluntary control system would be adopted and that the domestic consumers would switch from electric heating to wood or oil when requested to do so by the operators. No decision has yet been taken on billing for domestic electricity consumption.

The operation of the electricity supply system, comprising the mini-hydro and diesel generation, will progress in three stages:

The first period of operation will be for the first few months until early summer, 1985. The presence of downstream ice reduces the maximum power output of the mini-hydro to approximately 600 kW. This coincides with the period of minimum energy capacity due to the reduced river inflow, coupled with the inability to synchronise the existing diesel generators onto the system with the mini-hydro connected. Each of these difficulties will be removed from mid-May onwards, but until that time the diesel unit will be permanently connected to the system and will supply the difference between the total community demand and the mini-hydro output. There may therefore be a greater consumption of diesel fuel than would be expected in later years.

The second period will be from summer 1985 to summer 1986, the first full operating season. The combined mini-hydro/diesel powerhouse will be commissioned and the operators will be familiar with the techniques of managing the mini-hydro output, forecasting load demands and controlling the electric heating load. The community will have gained experience in the voluntary control of electric heating and with the requirement to switch to oil or wood when required.

The third period will be from the summer of 1986 onward. During this period, experience gained from the first and subsequent years of operation will be used to modify and update the EMS operating rules to better satisfy the needs of the community.

The first full year of operation of the mini-hydro will be carefully monitored; water levels, power and energy production at the mini-hydro and at the diesel station will be recorded and analysed and the use of heating oil and wood will be carefully evaluated.

For the spring of 1986, the following information/data will be available;

- exact value of BEL and its fluctuations during the day
- more precise value of the total heating demand
- evaluation of the performance of the operators and
- evaluation of the difficulties encountered by the population in dealing with the energy management procedures and an evaluation of their degree of awareness of the needs for energy conservation.

This information will enable one to review, in detail, the presently proposed Energy Management System and to decide on how effectively it has been used and what changes or improvements could be made. Some of these improvements could be:

- Improving the voluntary switching system presently adopted
- Adopting a dual electrical tarif system and equiping every house and building with electricity meters and
- Installing a sophisticated automatic switching system in every home, controlled by a central microprocessor.

APPENDIX A

TERMS OF REFERENCE

AMENDMENT #2
6805-7000-02

AMENDMENT TITLE: WEMINDJI ENERGY MANAGEMENT SYSTEM (EMS) Services for Study of Available EMS options

Amendment to Agreement that took place on the 29th day of March 1983 between Sakami Eeyou Corporation as agent for the Old Factory Band and SNC Inc.

Article 1: The mandate is described in Annex "A" to this amendment and is summarized as follows:

To analyse and evaluate the available data on the energy sources and the energy demands of the community of Wemindji and to study the Energy Management Systems (EMS) that could be introduced to minimize the overall energy costs to the community. At the conclusion of the study, recommendations will be made as to the most appropriate EMS for Wemindji and budget costs will be presented.

Article 2: To perform the services described in Article 1, SNC will be remunerated on the basis of a firm price for manpower of $34 800.00, with eligible expenses reimbursed at cost up to a maximum of $8 000.00.

Article 3: Remuneration will be paid to SNC in five (5) equal monthly payments of $8 560 from December 1984 to April 1985.

Unless otherwise stated in this amendment, terms and conditions of the above mentioned agreement remain unchanged.

IN WITNESS WHEREOF, the parties hereto have caused this Amendment #2 to be executed by their respective officers duly authorized to do so on this day of 1984.

SAKAMI EEYOU CORPORATION
Per:
Name:
Title:
Date:

WITNESS

SNC INC.
Per:
Name:
Title:
Date:

WITNESS

ANNEX "A"

WEMINDJI ENERGY MANAGEMENT SYSTEM (EMS)
SERVICES FOR STUDY OF AVAILABLE EMS OPTIONS

BACKGROUND

A meeting was held at Wemindji on the 30th of October, 1984 at which the Sakami Eeyou Corporation (SEC), the department of Energy Mines and Resources (EMR), the Department of Indian Affairs and Northern Development (DIAND) and SNC were represented. The general format and objectives of the EMS study were discussed and it was agreed that SNC should prepare a description of the aims and methodology of the EMS, with the associated Schedule of Activities. This document is the response to that decision.

The Methodology described represents the understanding of SNC on the objectives and approach of the EMS study. In addition, reference is made to the sources of data that will be used and the target dates for each activity.

METHODOLOGY

1. Introduction

At the request of the "Advisory Committee" which met in Wemindji on the 30th October, 1984, the following Methodology has been prepared by SNC to reflect the WORK SCOPE which formed part of the Agreement between the Sakami Eeyou Corporation (SEC) and the Department of Energy Mines and Resources (EMR). The basic objectives are the same as those proposed in the SNC document: "Energy Mangement Systems. An evaluation of energy management systems in remote communities", which was presented in March, 1984. The main differences are due to the time lapse between the original proposal and the contract award, during which period additional data has become available which will be reviewed in the EMS study. In addition, preliminary analyses have been made in anticipation of the official start of the study.

In the following text reference is made to the Work Scope from the agreement between EMR and the SEC and to the Schedule of Activities presented in Figure 1 of this Annex.

2. Contract Award

We understand that the agreement between the Sakami Eeyou Corporation and the Canadian Government was signed on the 24th of October, 1984. Consequently, in the Schedule of Activities of Figure 1, this is shown as the date of Contract Award and the "official" starting date of the EMS study.

3. Advisory Committee

In both the original SNC document and in the Work Scope, it was recommended that an Advisory Committee be established to provide guidance and advice, and to insure the active participation of all interested parties in the EMS study. Although formal appointees have not been made to the committee, personnel from EMR, DIAND, and SNC met with representatives of the Sakami Eeyou Corporation in Wemindji on the 30th October, 1984 to discuss the aims and scope of the EMS study. Therefore, in Figure 1 this is shown as being the Initial Meeting of the Advisory Committee.

4. Review of Existing Data

A number of reports have been produced relating to the energy supply and demand at Wemindji. In particular, two reports have been issued in their final form during the last month. Each of these reports will be analysized to establish the availability of different energy sources and the energy demands within the community. No further work will be undertaken to obtain fresh data on energy sources, energy demand or energy conservation at Wemindji. The EMS study will concentrate on the analysis and use of existing data.

4.1 Energy Audits

As part of its preliminary work in the evaluation of energy sources at Wemindji, SNC determined an approximate community energy demand forecast for a 50-year planning period. Subsequently, a study was commissioned by DIAND and the consultants Rousseau, Sauvé, Warren Inc. (RSW) produced a report titled: "ENERGY REVIEW". This report is now available in its final form. As part of a "Firewood Demand Study" (see 4.2 below) the consultants COGESULT reviewed the domestic space heating demand for three communities, including Wemindji. This report is now available. The data and conclusions included in these reports will be compared with the SNC data and an overall energy demand forecast will be established for Wemindji. Should any fundamental differences be found between the three sets of data, the views of the Advisory Committee will be sought as to which data should be used.

4.2 Firewood

The consultants Cogesult were commissioned to conduct a study of the availability and costs of Firewood as an energy source at Wemindji. The final version of the COGESULT report: "A Firewood Demand and Supply Study for the Communities of Eastmain, Wemindji and Waskaganish", September 1984 is now available for review and analysis by SNC as part of the EMS study. At the time of writing of this methodology the report has not been received. However, its data will be included in the evaluation of the energy sources available to Wemindji.

4.3 Mini-Hydro

The Maquatua mini-hydro will be commissioned in mid-November, 1984. Once in service, it will be capable of supplying the majority of the community energy demand for most of the year, although there will be limitations to the use of electrical energy for space heating in the winter months. The benefits and limitations of the mini-hydro energy will be included in the overall evaluation of the energy sources for the community.

4.4 Conservation

A number of in-depth evaluations have been carried out by the Cree Housing Corporation into the costs and benefits of energy conservation measures as applied to the homes and public buildings in Wemindji. This includes the installation of optimum energy conservation techniques in the new homes and the retrofitting of insulation to existing homes. At the October 30th meeting of the Advisory Committee, the representatives of the Sakami Eeyou Corporation stated that all required Energy Conservation data was already available and that no further study was required. Sakami Eeyou Corporation will provide the required data from Cree Housing Corporation studies.

4.5 Diesel Generation

The records of previous diesel generation will be supplied by DIAND so that the energy supply can be correlated with the calculated energy demands, both past and future. We understand that records are available on a monthly basis for the past several years for the fuel consumed and the energy supplied. In addition, records will be supplied of the peak and minimum loads as a function of time of day and of season.

Note: Availability of Data

It is shown in the Schedule of Activities of Figure 1 that all existing data on energy sources, energy demand and energy conservation is assumed to be in the hands of SNC by the beginning of week 3 of the study, that is by the 9th of November, 1984. This is necessary to meet the deadlines imposed by the overall study schedule of 20-weeks.

5. Community Energy Demand

The present energy demand for Wemindji will be established from the results of the RSW, COGESULT and SNC reports. The demand will be divided into the Basic Electric Load (BEL) and the Space Heating Load (SHL) for homes and public buildings. The demand will be expressed as a function of season, with due account of the life-styles of the community. Separate scenarios will be included to account for unusually cold (or warm) periods of weather which will distort the demand pattern which is based on heating "degree-days" per month.

6. Energy Demand, With and Without Conservation

Data on the costs and benefits of energy conservation measures will be provided by the Sakami Eeyou Corporation, as agreed in the October 30th meeting. This data will be reviewed and analysed to establish its impact on the forecast energy demands and the costs of energy supply for the planning periods. Three demand scenarios will be considered: continue with existing levels of conservation; introduce low-cost energy conservation; apply more extensive energy conservation.

7. Energy Demand Analysis

The forecast energy demands will be determined for 5, 10, 20, 30 and 50-year planning periods with a number of variables being considered. These will include levels of energy conservation, population growth and building construction, planned introduction of new industry, matching of energy demand with the appropriate energy source, etc.

8. Evaluation of Energy Sources

It has been established that the viable energy sources available to Wemindji are mini-hydro, wood, heating-oil and diesel generation. The capabilities and limitations of each of these sources will be established with due regard to the matching of energy demand to energy source to limit the overall cost of energy to the community.

9. Distribution System

The distribution system has recently been refurbished and the necessary additions have been made to connect the mini-hydro generation to the community. In addition, arrangements have been made to transfer the diesel generation from its existing location to a new position close to the mini-hydro. The distribution is therefore in an excellent condition to supply the requirements of the mini-hydro and diesel generation and the community loads. The analysis of the distribution will be limited to modifications that are required to incorporate the requirements of the EMS system.

10. Discussion Document on EMS

A number of options exist for the EMS at Wemindji, ranging from a "do-nothing" approach to a sophisticated telecontrol and metering system for each building in the community. These options have been summarized in Section 11 item D of the Work Statement in the Canada/Sakami Eeyou Study Agreement. A discussion document will be prepared for the Advisory Committee outlining the operating characteristics, benefits and limitations of each of the EMS options.

11. Selection of Preferred EMS Options

The advisory committee will discuss the various EMS options that have been considered for Wemindji and will chose one or more for a more detailed evaluation by SNC. At this meeting, the various options for energy sharing and billing will also be discussed with special reference to the acceptability of the different scenarios by the community. This meeting is scheduled for the 15th of January, 1985.

12. Preliminary EMS Design

A preliminary design will be prepared for the chosen EMS option(s). The design will incude a description of operating principles, advantages and drawbacks, equipment descriptions and approximate costs, etc. Documentation will be prepared to assist the Band Council community presentations. This presentation is scheduled for the 22nd of January, 1985, as a target date.

13. Detailed EMS Design

Following the community presentations on the available EMS options, a decision will be made as to which system is most appropriate to Wemindji. This system will be analysed in more detail and a design and performance specification will be produced, together with budget estimates of the capital and operating costs, and the resuting benefits to the community.

14. Preliminary and Final Reports

Preliminary report preparation will begin early in the study and will be completed by the end of week 17, with a target date of the 15th of February, 1985. An allowance of 2 to 3-weeks has been made for the review of the preliminary report and it is projected that the final report will be issued at the end of week 20, that is by the 15th of March, 1985. The contents of the report will follow the draft table of contents as given in section 14 of the Work Statement in the Canada/Sakami Eeyou agreement.

APPENDIX B

ENERGY DEMAND FORECASTS

TABLE 18

SIMULATION OF ENERGY SUPPLY *

(IN MILLION kWh)

YEAR	ENERGY DEMAND			ENERGY SUPPLY			
				Basic Elec. Needs		Heating	
	Basic Elec. Needs	Heating	Total	Mini-Hydro	Diesel	Mini-Hydro	Oil/Wood
1982	0,84	5,60	6,43	0,00	0,84	0,00	5,60
1983	0,90	6,11	7,01	0,00	0,90	0,00	6,11
1984	0,94	6,41	7,34	0,94	0,00	3,38	3,03
1985	1,01	6,84	7,85	1,01	0,00	3,44	3,40
1986	1,08	7,35	8,43	1,08	0,00	3,53	3,82
1987	1,18	8,30	9,48	1,18	0,00	3,60	4,70
1988	1,24	8,50	9,73	1,24	0,00	3,61	4,89
1989	1,29	8,68	9,96	1,29	0,00	3,59	5,09
1990	1,35	8,98	10,33	1,35	0,00	3,59	5,39
1991	1,41	9,30	10,71	1,41	0,00	3,58	5,72
1992	1,49	9,61	11,11	1,49	0,00	3,56	6,05
1993	1,53	9,84	11,37	1,53	0,00	3,60	6,24
1994	1,58	10,08	11,66	1,58	0,00	3,63	6,45
1995	1,63	10,32	11,95	1,63	0,00	3,65	6,67
1996	1,68	10,57	12,25	1,68	0,00	3,67	6,90
1997	1,73	10,83	12,56	1,73	0,00	3,67	7,16
1998	1,78	11,09	12,87	1,78	0,00	3,67	7,42
1999	1,83	11,36	13,19	1,83	0,00	3,66	7,70
2000	1,89	11,63	13,52	1,89	0,00	3,62	8,01
2001	1,94	11,91	13,85	1,94	0,00	3,59	8,32
2002	2,00	12,20	14,37	2,00	0,00	3,55	8,65
2003	2,06	12,50	14,56	2,06	0,00	3,50	9,00
2004	2,12	12,80	14,92	2,12	0,00	3,44	9,36
2005	2,19	13,11	15,30	2,19	0,00	3,38	9,73
2006	2,25	13,43	15,68	2,25	0,00	3,29	10,14
2007	2,32	13,75	16,07	2,32	0,00	3,19	10,56
2008	2,37	14,04	16,41	2,37	0,00	3,17	10,87
2009	2,43	14,34	16,77	2,43	0,00	3,17	11,17
2010	2,48	14,64	17,12	2,48	0,00	3,15	11,49
2011	2,54	14,95	17,49	2,54	0,00	3,14	11,81
2012	2,60	15,26	17,86	2,60	0,00	3,11	12,15
2013	2,66	15,59	18,25	2,66	0,00	3,07	12,52
2014	2,72	15,92	18,64	2,71	0,01	3,04	12,88
2015	2,78	16,25	19,03	2,77	0,01	2,99	13,26
2016	2,85	16,59	19,44	2,83	0,02	2,94	13,65
2017	2,91	16,94	19,85	2,89	0,02	2,89	14,05
2018	2,98	17,30	20,28	2,95	0,03	2,84	14,46
2019	3,05	17,67	20,72	3,01	0,04	2,78	14,89
2020	3,11	18,04	21,15	3,07	0,04	2,71	15,33
2021	3,19	18,42	21,61	3,15	0,04	2,64	15,78
2022	3,26	18,81	22,07	3,20	0,06	2,57	16,24
2023	3,34	19,21	22,55	3,27	0,07	2,50	16,71
2024	3,42	19,61	23,03	3,33	0,09	2,40	17,21
2025	3,50	20,03	23,53	3,41	0,09	2,31	17,72
2026	3,58	20,45	24,03	3,47	0,11	2,20	18,25
2027	3,66	20,88	24,54	3,54	0,12	2,10	18,78
2028	3,74	21,32	25,06	3,60	0,14	1,98	19,34
2029	3,83	21,77	25,60	3,67	0,16	1,86	19,91
2030	3,92	22,23	26,15	3,74	0,18	1,73	20,50
2031	4,01	22,70	26,71	3,81	0,20	1,60	21,10
2032	4,10	23,18	27,28	3,88	0,22	1,44	21,74

* Source: Wemindji Energy Study, prepared for La Société d'énergie de la Baie James by SNC, September 1982, table 18, page 7-3.

ENERGY AUDIT SAMPLES *

community house model	WASKAGANISH	EASTMAIN	WEMINDJI	TOTAL
Cedar house	7	14	6	27
White house	4		2	6
Red house		1		1
Model I	16		7	23
Model II	3		2	5
Total	30	15	17	62

The heating energy demand per house in 1983 was:

Cedar houses with unfinished basements	30 400 KWh
Cedar houses with finished basements	25 000 KWh
White houses	27 200 KWh
Red houses	37 900 KWh
Green houses	35 000 KWh
Models 1	20 720 KWh
Models 11	19 800 KWh

The total heating energy demand per community is presented in Table 1.1.2.

---

* Source: Firewood Demand and Supply Study for Eastmain, Wemindji and Waskaganish, Quebec, prepared for the Grand Council of the Crees (of Quebec) and the Cree Regional Authority by Cogesult Inc. with contributions from Indian and Northern Affairs Canada and the Remote Community Demonstration Program of Energy, Mines and Resources Canada, Table 1.1.1, page 10.

TOTAL HEATING ENERGY DEMAND * PER COMMUNITY

(KWh)

communities / house model	WASKAGANISH		EASTMAIN		WEMINDJI	
	Number of houses	KWh	Number of houses	KWh	Number of houses	KWh
Cedar houses with unfinished basement	44	1337600				
Cedar houses with finished basement			43	1075000	66	1650000
White houses	25	680000			6	163200
Red houses			2	75800		
Green houses			1	35000		
Model I	60	1243200			40	828800
Model II	24	475200	14	277200	12	237600
Total	153	3736000	60	1463000	124	2879600

* Source: Firewood Demand and Supply Study for Eastmain, Wdmindji and Waskaganish, Quebec, table 1.1.2, page 11.

MAXIMUM ANNUAL FIREWOOD DEMAND FOR RESIDENTIAL HEATING *

(Cords of wood)

years / communities	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98
Waskaganish	1033	1102	1102	1102	1202	1202	1272	1272	1272	1341	1341	1411	1411	1411	1480
Eastmain	430	430	456	444	444	405	405	405	405	405	405	405	475	475	475
Wemindji	883	883	948	1018	1018	1018	913	805	875	875	875	875	944	944	944
	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13
Waskaganish	1480	1550	1658	1658	1658	1658	1658	1658	1970	1970	1970	1970	1970	1970	1970
Eastmain	475	475	475	475	544	544	544	544	544	544	613	613	613	613	613
Wemindji	1014	1014	1014	1083	1083	1083	1153	1153	1222	1222	1222	1292	1292	1361	1361

---

* Source: Firewood Demand and Supply Study for Eastmain, Wemindji and Waskaganish, Quebec, table 1.2.1, page 15

Comparison of total demand for 30 years
to preferential harvesting areas expected yield *

Community	Total demand (m^3)	expected yield (m^3)	total demand/ expected yield
Waskaganish	110,200	538,370	20%
Eastmain	35,400	491,398	7%
Wemindji	75,600	585,084	13%

---

* Source: Firewood Demand and Supply Study for Eastmain, Wemindji and Waskaganish, Quebec, table 1.2.8, page 30.

TOTAL YIELD DISTRIBUTION PER SPECIES FOR EACH COMMUNITY *

COMMUNITY / SPECIES		A R E A					
		WASKAGANISH (m3)	WASKAGANISH (%)	EASTMAIN (m3)	EASTMAIN (%)	WEMINDJI (m3)	WEMINDJI (%)
BALSAM FIR	(SAB)	87 045	9,9	62 460	9,5	92 771	9,0
WHITE SPRUCE	(EPB)	101 604	11,6	94 519	14,4	259 095	25,1
BLACK SPRUCE	(EPN)	648 422	74,0	484 019	73,8	656 436	63,6
JACK PINE	(PIG)	1 670	0,3	7 263	1,1	8 422	0,8
TAMARAC	(MEL)	2 990	0,3	3 530	0,5	6 155	0,6
BALSAM POPLAR	(PEB)	14 056	1,6	521	0,1	2 975	0,3
TREMBLING POPLAR	(PET)	10 109	1,2	1 074	0,2	1 914	0,2
WHITE BIRCH	(BOP)	10 004	1,1	2 707	0,4	4 498	0,4
TOTAL		875 900	100,0	656 093	100,0	1 032 266	100,0

---

* Source: Firewood Demand and Supply Study for Eastmain, Wemindji and Waskaganish, Quebec, table 1.2.3, page 18.

SUMMARY OF FORECAST ENERGY CONSUMPTION *

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	2007	2032
POPULATION	768	785	802	820	838	856	875	895	914	934	955	1285	2108
RESIDENCES - NO.	114	130	141	144	147	150	153	156	159	162	165	220	350
ENERGY DEMAND - BASIC MWh/ANNUM													
Av. demand per residence	6.1	7.9	10.0	10.3	10.4	10.4	10.4	10.4	10.5	10.6	10.7	11.0	11.0
Total demand - residences	695	1030	1410	1480	1510	1560	1591	1623	1671	1717	1766	2320	3850
- commercial	25	28	28	30	30	33	33	36	36	36	36	42	55
- institutions (exist.)	50	67	70	70	73	88	88	88	92	94	94	103	111
- utilities (lighting & pumping)	50	51	52	54	56	58	59	60	71	72	74	90	100
- trace heating		50	50	50	52	54	56	58	60	62	65	85	140
- new airstrip				50	50	50	50	50	50	50	50	50	50
- arena lighting		25	50	50	50	50	50	50	50	50	50	50	50
- arena compressor		100	300	300	300	300	300	300	300	300	300	300	300
TOTAL BASIC DEMAND - MWh/ANNUM	820	1351	1960	2074	2121	2193	2227	2265	2330	2381	2435	3040	4656
- MWh/MONTH	70	113	163	173	177	183	186	189	189	198	203	253	308
ENERGY DEMAND - HEATING													
Total Area residential (m^2)	7820	9960	11370	11620	11860	12180	12580	12990	13730	14840	16200	24900	45600
Total Demand " (MWh/annum)	3060	3365	3695	3785	3875	3965	4055	4145	4230	4320	4410	6565	10450
Total Area commercial (m^2)	900	1000	1000	1100	1100	1200	1200	1200	1300	1300	1300	1500	2000
Total Demand " (MWh/annum)	340	375	375	415	415	450	450	450	490	490	490	565	750
Total Area - institutions - m^2	3300	4400	4640	4840	4840	5840	5840	5840	6240	6240	6240	6790	7290
Total Demand " (MWh/annum)	1175	1400	1510	1510	1550	1940	1940	1940	2015	2085	2085	2310	2500
TOTAL HEATING DEMAND (MWh/ANNUM)	4575	5145	5580	5710	5840	5355	6445	6535	6735	6895	6985	9440	13700

* Source: Wemindji Energy Review, Final Report, prepared for Ministère des Affaires indiennes et du Nord Canada, by Rousseau, Sauvé, Warren Inc., October 1984, table 3-2, page 3/-7-.

Note from SNC: The figures do not reflect consumption associated with 1983 diesel operation experience.

WEMINDJI - ENERGIE
DEMANDE TOTALE - 1983 - 2032 *

ANNEE	BASE MWH	CHAUFFAGE MWH DOM.	INST.	TOTAL	ENERGIE TOTAL
1983	3160	2091	1775	3866	7026
1984	3855	2555	1885	4440	8295
1985	2074	3785	1925	5710	7784
1986	2121	3875	1965	5840	7961
1987	2193	3965	2390	6355	8548
1988	2227	4055	2390	6445	8672
1989	2265	4145	2390	6535	8800
1990	2330	4230	2505	6735	9065
1991	2381	4320	2575	6895	9276
1992	2433	4410	2575	6985	9420
1993	2475	4565	2575	7140	9615
1994	2516	4690	2575	7265	9781
1995	2556	4845	2575	7420	9976
1996	2596	5095	2575	7670	10266
1997	2637	5120	2575	7695	10332
1998	2677	5275	2665	7940	10617
1999	2717	5425	2665	8090	10807
2000	2758	5550	2663	8215	10973
2001	2798	5705	2665	8370	11168
2002	2838	5860	2775	8635	11473
2003	2879	6001	2795	8796	11675
2004	2919	6141	2815	8956	11875
2005	2959	6283	2835	9118	12077
2006	3000	6424	2855	9279	12279
2007	3040	6565	2875	9440	12480
2008	3105	6721	2890	9611	12716
2009	3169	6877	2905	9782	12951
2010	3234	7033	2920	9953	13187
2011	3299	7189	2935	10124	13423
2012	3363	7345	2950	10295	13658
2013	3428	7500	2965	10465	13893
2014	3492	7655	2980	10635	14127
2015	3557	7810	2995	10805	14362
2016	3622	7965	3010	10975	14597
2017	3686	8120	3025	11145	14831
2018	3751	8215	3040	11255	15006
2019	3816	8310	3055	11365	15181
2020	3880	8405	3070	11475	15355
2021	3945	8500	3085	11585	15530
2022	4010	8595	3100	11695	15705
2023	4074	8810	3115	11925	15999
2024	4139	9025	3130	12155	16294
2025	4204	9240	3145	12385	16589
2026	4268	9455	3160	12615	16883
2027	4333	9670	3175	12845	17178
2028	4397	9826	3190	13016	17413
2029	4462	9982	3205	13187	17649
2030	4527	10138	3220	13358	17885
2031	4591	10294	3235	13529	18120
2032	4656	10450	3250	13700	18356

* Source: Wemindji Energy Review, Final Report, Appendix C, page C-1

Note from SNC:
These figures reflect continuation of diesel generation. They are common to all options and thus a negligible effect on present worth comparisons.

APPENDIX C

ENERGY SUPPLY AND DEMAND

WEMINDJI ELECTRICITY SUPPLY - FUEL CONSUMPTION DATA

The following information was prepared from a telephone conversation with DIAND Québec, October 18th, 1984.

FUEL CONSUMPTION September 1982 - August 1984

1983	
September	69,900 litres
October	82,300
November	87,700
December	110,900
1984	
January	116,800
February	103,000
March	105,900
April	91,500
May	71,100
June	87,700
July	71,450
August	71,850
-Total	1,069,900 litres

SHIPMENTS OF FUEL

1982/83	720,000 litres
1983/84	1,663,055 litres
1984/85	1,000,000 litres

THIRD PARTY CONSUMERS

Consumption for 8 April '83 to 7 May '84

CUSTOMER	CONSUMPTION (kWh)
Cree School Board	507,600
Anglican Mission	31,250
Air Creebec	2,050
Cree Board Health	153,610
Cree Construction	251,150
Cree Housing Corp.	27,360
Hudson Bay Company	44,300
M.T.P.A. (Sûreté du Québec)	15,190
Sotel	34,740
Telesat	26,510
TOTAL	1,093,760 kWh

APPENDIX D

MEETINGS AND PRESENTATION

MEETING AT WEMINDJI (OCTOBER 30TH, 84) WITH BAND, MR. E. SKINNERLAND, DIAND AND EMR

1.0 GENERAL

The overall objectives were to discuss the formation of the Wemindji "Joint Committee" which will be responsible for the operation of the combined mini-hydro, diesel generation and distribution system at Wemindji. In addition, the Energy management System (EMS) study objectives were discussed at a meeting with EMR.

2.0 DATA RECEIVED

2.1 Diesel generator load on 30th October, 84 was 630 kW. Temperature was around -2°C and it was windy. (Note: Temperature at about the same date last year was approximately the same, but with light snow, and the load was 575 kW).

2.2 DIAND Fuel Consumption figures were supplied by DIAND. The figures covered the seasons, 1983/84 and the fuel supply for 1984/85. (See Appendix C).

2.3 Minimum Summer Load. The minimum continuous load on the mini-hydro is 100 kW. Below this, the unit will have to be disconnected. DIAND agreed to provide figures for the minimum summer load on the present diesels as an indication of the potential minimum mini-hydro load in the future.

3.0 EMS STUDY

a) SNC requested existing reports from RSW and Cogesult studies to begin the EMS study. E. Skinnerland stated that SNC has the most recent "final report" from RSW and that he could provide a coy of the Cogesult report if necessary. However, EMR agreed to provide SNC with a copy of the Cogesult report as soon as the final version is received.

b) Target Dates

Committee meeting (Montréal)	15th January, 1985
Preliminary Report	15th January, 1985
Final Report	15th March, 1985

c) It was stressed that the work of SNC would be a review of work already carried out by SNC, Cogesult, RSW and others.

MEETING AT WEMINDJI

THURSDAY, JANUARY 24, 1985

HIGHLIGHTS

1. ATTENDANCE

Messrs E. Skinnarland
Chief W. Hughboy
B. Atsynia
F. Georgekis
H. Goergekis
M. Lamanque
K. Rothenburg
Ch. Guillaud
A.B. Turner

2. EMS STUDY CONTRACT BETWEEN SAKAMI EEYOU AND SNC

A signed copy was received by SNC and Sakami Eeyou. Copies were also retained by EMER and E. Skinnarland.

3. INITIAL OPERATION OF MINI-HYDRO AND DIESEL GENERATION

Three options were discussed:

a) Operate mini-hydro at constant power output to maintain reservoir at fixed level. Diesel generator output will be varied to satisfy load fluctuations.

b) Operate mini-hydro alone (no diesel) to satisfy full load. If water level is reduced to minimum permissible value, shut down mini-hydro and operate diesel until reservoir increases to required operating level. Then start up mini-hydro and shut down diesel.

c) Operate mini-hydro to supply full load. If reservoir is reduces towards minimum level, operate diesel at sufficient output to increase water level. Shut down diesel when reservoir reaches required level.

It was agreed that the operators should chose between options b) and c). The choice would depend on their operating experience during the initial weeks.

DIAND would assist in operating the diesel generation in parallel with the mini-hydro.

4. EXISTING OPERATING DATA

a) Third party consumers used 990,000 kWh in the period mid-March 1983 to mid-April 1984.

b) Diesel generation energy equivalence 3.03 kWh/litre.

Diesel generation costs are: 0.67¢/kWh (1984) (see note 1)
Diesel generation billing is: 0.33¢/kWh (1984)

Note 1: Subsequently, DIAND indicated by telephone that diesel generation costs are 35¢/kWh with fuel costs of 45¢/litre, including delivery.

c) DIAND agreed to supply details of monthly and daily load supplied at Wemindji (peak, average and minimum) for previous years.

d) Energy Conservation

1. Sakami Eeyou will supply, as soon as possible, data on the potential savings and costs of energy conservation measures at Wemindji.

2. Energy conservation measures, especially insulation and air infiltration, are assumed to be a "optimized" for the new houses.

   Retro-fitting of insulation is not worthwhile for older houses (cedar type) as they will be replaced within five years.

   EMR will produce curricula for schools to educate students in the needs, techniques and benefits of energy conservation.

e) Mini-hydro output at 15.00 hrs on the 26th January 1985, was 600 kW. Successful load shedding had been performed at 500 kW.

5. DRAFT TABLE OF CONTENTS

A draft Table of Contents for the EMS Study Report was reviewed; no changes were suggested. The preliminary EMS report will be based on this Table of Contents. Copies will be sent by February 15th to Sakami Eeyou, EMR and DIAND.

6. MONITORING STUDY

6.1 A data logger has been installed but not commissioned. When commissoned, the operators will be able to read its register stores manually. However, full operation requires a data-link connection, by telephone link, to Montréal. The lines are already present, so Sakami Eeyou agreed to contact SOTEL to request connection of the necessary telephone installation as soon as possible.

6.2 Original program indicated that the EMS installation would be completed by November 1985.

Delays in the start date for the EMS study and in the commissioning of the mini-hydro imposed a new schedule of activities.

- Completion of EMS Study : End of March 1985
- Installation of EMS Equipment : October 1985
- Monitoring Program : October 1985 to March 1986
- Completion of Monitoring Program : April 1986

6.3 Sakami Eeyou will supply details on wood supply program and oil consumption (diesel and heating).

7. FUTURE ACTIVITIES

- EMS presentation to Wemindji community: 27th January 1985
- Hugo Georgekis to contact SNC to supply details and conclusions of EMS presentation.
- DIAND to supply details as soon as possible to SNC, of the history of diesel generator output.
- W. Hughboy will provide to SNC details of Cree Construction conclusions on Energy Conservation.
- SNC to inform H. Georgekis of the permitted phase unbalance limits of mini-hydro generator.
- SNC to produce draft EMS report by February 15, 1985.
- Comments on draft report will be returned to SNC by February 28, 1985.
- Final report target date is March 15, 1985. Deadline March 28, 1985.

EMS PRESENTATION

A meeting at the Band Office was held on Sunday, January 27, 1985. At the meeting, the proposed energy management system study was discussed.

A brief description of the mini-dam was given. Also, the relationship between the level of water in the reservoir and the amount of power output was discussed.

A description was given as to what the basic electric load (BEL) is. Further, it was explained that when there is excess water, available power output exceeds BEL and if the excess power is not used water will be spilled over the dam. Water spilled over the dam is wasted energy.

Electric heating (plenum heaters) was discussed. It was explained that plenum heaters can be installed in the existing furnaces. However, the only problem would be to control the use of such heaters. The various options of load management were enumerated and discussed.

1) No restriction on the use of power. It was explained that this option would quickly draw down the reservoir and it would be necessary to start the diesel. This option would cost too much.

2) Dual-Tariff metering. It was explained that meters would be installed in all the houses to measure the amount of power used in each house. The tenants would pay two rates of power. People would be alloted a certain amount of power for their basic electric load and any power used in excess would be considered as heating load. People would pay a cheaper rate for their basic electric laod and a higher rate for their heating load. It was further explained that this option could result in reservoir draw down and diesel generation supplement to meet the load demand.

3) Voluntary switching of heating load. This option necessitates the co-operation of the people. People would be notified how much power is available each day for electric heating. When the water level in the reservoir reached a certain level, people would be asked to switch off their plenum heaters and if everyone co-operates, it would not be necessary to start the diesel generator. This option would be by far be the cheapest.

4) Remote switching of heating load. It was explained that it is possible to install a remote switching system where the operator could switch on or switch off heating load at will from the powerhouse. This option would only be installed if the voluntary option did not succeed. This option would be very expensive but it would ensure reservoir level and load management.

Of the four options, the people present at the meeting felt that option 3 (Voluntary switching) could work. Those present felt that they would not hesitate to switch off their electric heating when asked to do so. Most people heat their houses seven to eight months of the year. If they could use electric heating for part of that time, it would be a substantial saving in fuel and wood. Those present said they would not object to electric heating by districts so long as their system is managed fairly.

The meeting adjourned at this time.

APPENDIX E

EQUIPMENT

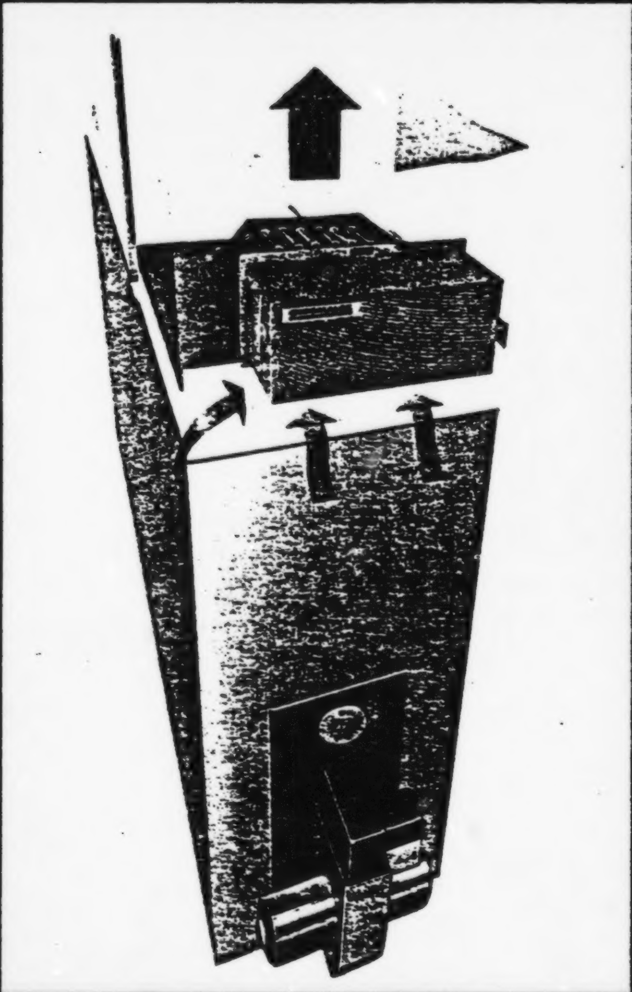
CHROMALOX

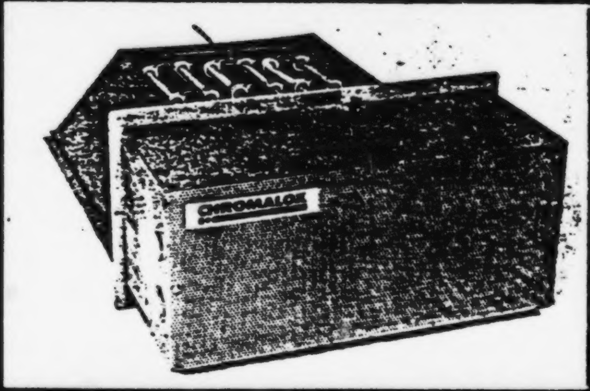
CCSL-429
Effective October, 1983

Place in section
400 of your
Chromalox binder

Plenum Heaters – Type DEP

Another Chromalox "Off-Oil" Product





LS Series:
with electronic load shedding for installation with existing 60 amp, 100 amp or 125 amp electrical services.

S Series:
for installation with electrical services that have enough unused capacity to accommodate the full electric heating load.

Chromalox plenum heaters are designed and built by a company who's slogan "First Name In Electric Heat" has been synonymous with quality and dependability for over fifty years.

By installing a Chromalox plenum heater in your present oil furnace, you add the many advantages of electric heating while retaining the comfort of forced warm air heating, humidification and filtering.

A Chromalox DEP plenum heater installation qualifies for COSP grants (Up to $800.00 grant from Federal Government.) plus the "U" models qualify for Ontario Hydro incentives.

Comes complete with pre-punched baffles to fit plenums up to 24" x 26".

CHROMALOX
CANADA
A DIVISION OF CANADIAN CORPORATE MANAGEMENT COMPANY LIMITED

210 Rexdale Boulevard
Rexdale, Ontario
M9W 1R4
(416) 743-8000
Telex. 06-989333

Branch Offices

Montreal
243 Boul. Hymus
Pointe Claire, Que.
H9R 1G3
(514) 697-1131
Telex. 05-821520

Halifax
73 Tacoma Drive
Dartmouth, N.S.
B2W 3Y6
(902) 434-1290
(902) 434-1294
Telex 019-22859

Winnipeg
1865 Sargent Avenue
Winnipeg, Man. R3H 0E4
(204) 786-6811
Telex 07-57400

Vancouver
2455 Beta Avenue
Burnaby, B.C. V5C 5N1
(604) 294-1601
Telex 04-356650

Sales Offices
East to West

Newfoundland
P.O. Box 8532
Stn. A. St. John's
Newfoundland, A1B 3N9
(709) 895-3135

Moncton
567 Coverdale Road
Suite 10, Riverview
Moncton, N.B.
E1B 3K7
(506) 386-1110
Telex 014-2135

Quebec
2030 Boul. Pere Lelievre
Quebec, Que.
G1P 2X1
(418) 683-2198
Telex 051-3328

Ottawa
196 Bronson Avenue
Suite 304
Ottawa, Ont. K1R 6H4
(613) 235-4359
Telex 053-3547

North Bay
1332 Franklin St., Box 656
North Bay, Ont. P1B 2M3
(705) 472-6215

Calgary
Box 83, Stn "T"
Calgary, Alta. T2H 2G7
(403) 281-2366
Telex 038-28596

Standard Features:

- Hi limit controls (1 manual reset – 1 automatic reset)
- Two current transformers (LS series only)
- Plenum baffles – prepunched for easy mounting in plenum
- Electronic load shedding (LS series only)
- 2 stage, 2 wire room thermostat
- Proof of Oil sensor (if oil heat fails, electric heating is turned on automatically)
- Outdoor thermostat – field adjustable with tamper-proof mounting kit.

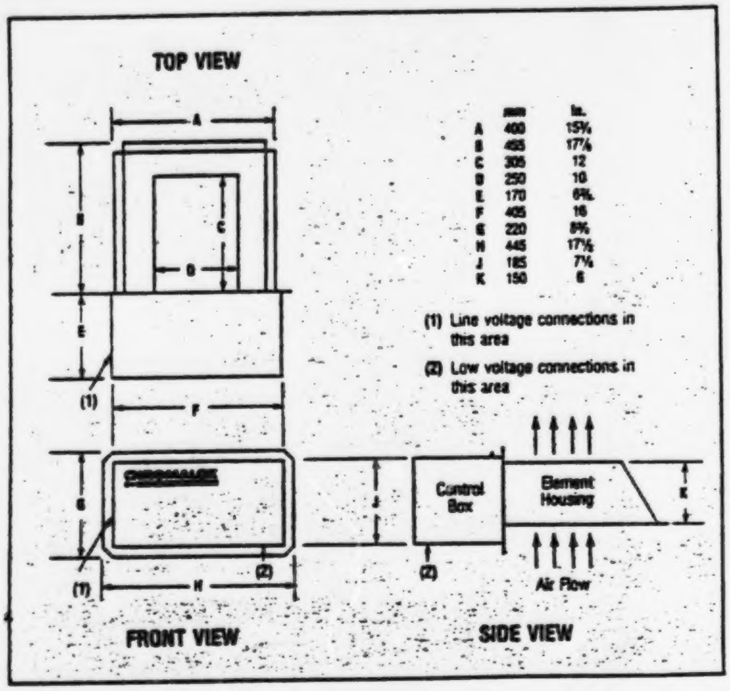
Chromalox DEP plenum heaters use standard outdoor thermostats. They do not require special "matching" electronic controls.

Automatic switching from electric heating to oil heating.

Unique "Flow Thru" design captures all the air from the furnace blower and directs it evenly over the electric elements.

DEP plenum heaters are not position sensitive in the plenum. They can be mounted on any side of the plenum.

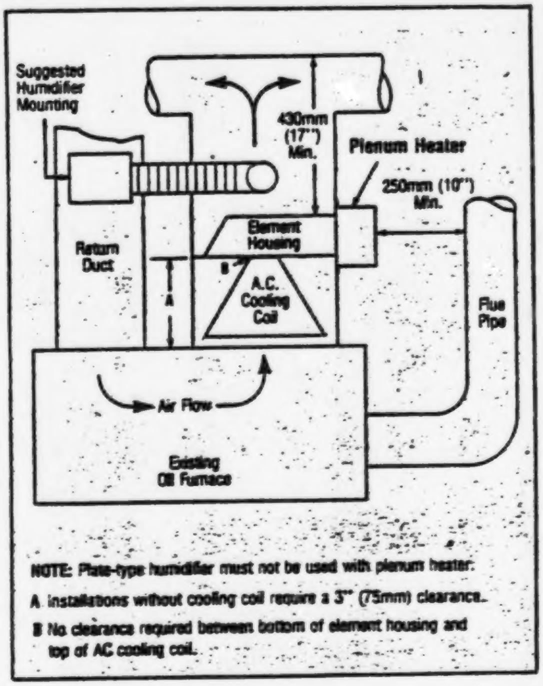
Compatible with existing humidifiers, air conditioning coils and electronic air filters.



	mm	in.
A	400	15¾
B	455	17⅞
C	305	12
D	250	10
E	170	6¾
F	405	16
G	220	8¾
H	445	17½
J	185	7¼
K	150	6

(1) Line voltage connections in this area

(2) Low voltage connections in this area



NOTE: Plate-type humidifier must not be used with plenum heater.

A Installations without cooling coil require a 3" (75mm) clearance.

B No clearance required between bottom of element housing and top of AC cooling coil.

Chromalox Model "DEP" Plenum Heater

Power Supply: 240V, 1φ, 60Hz

LS Series With Electronic Load Shedding

Model No.	KW	Service Entrance Size	Total Current (Amps)	Fuse Size (Amps)	Breaker Size (Amps)	Controlled Stages	Non-Controlled Stages	Max. Temp. Rise	Proof Of Oil Sensor
DEP-U9-LSC*	9	60/100 Amps	37.5	50	50	2 x 4.5 KW	None	60ºF	Built-In
DEP-U15-LSC*	15	100 Amps	62.5	80	80	3 x 5 KW	None	70ºF	Built-In
DEP-9-LSC	9	60/100 Amps	37.5	50	50	3 x 3 KW	None	60ºF	Built-In
DEP-U9-LSH*	9	60/100 Amps	37.5	50	50	2 x 4.5 KW	None	60ºF	Remote
DEP-U15-LSH*	15	100 Amps	62.5	80	80	2 x 5 KW	1 x 5 KW	70ºF	Remote
DEP-9-LSH	9	60/100 Amps	37.5	50	50	3 x 3 KW	1 x 3 KW	60ºF	Remote

S Series Without Electronic Load Shedding

Model No.	KW	Total Current (Amps)	Fuse Size (Amps)	Breaker Size (Amps)	Stages	Max. Temp. Rise	Proof Of Oil Sensor
DEP-9-SC	9	37.5	50	50	3 x 3 KW	60ºF	Built-In
DEP-U15-SC	15	62.5	80	80	3 x 5 KW	70ºF	Built-In
DEP-9-SH	9	37.5	50	50	3 x 3 KW	60ºF	Remote
DEP-U15-SH	15	62.5	80	80	3 x 5 KW	70ºF	Remote

*These models meet Ontario Hydro's "U Series" Requirements for Dual Energy Program Assistance

CSA approved LR34970

BBC
BROWN BOVERI

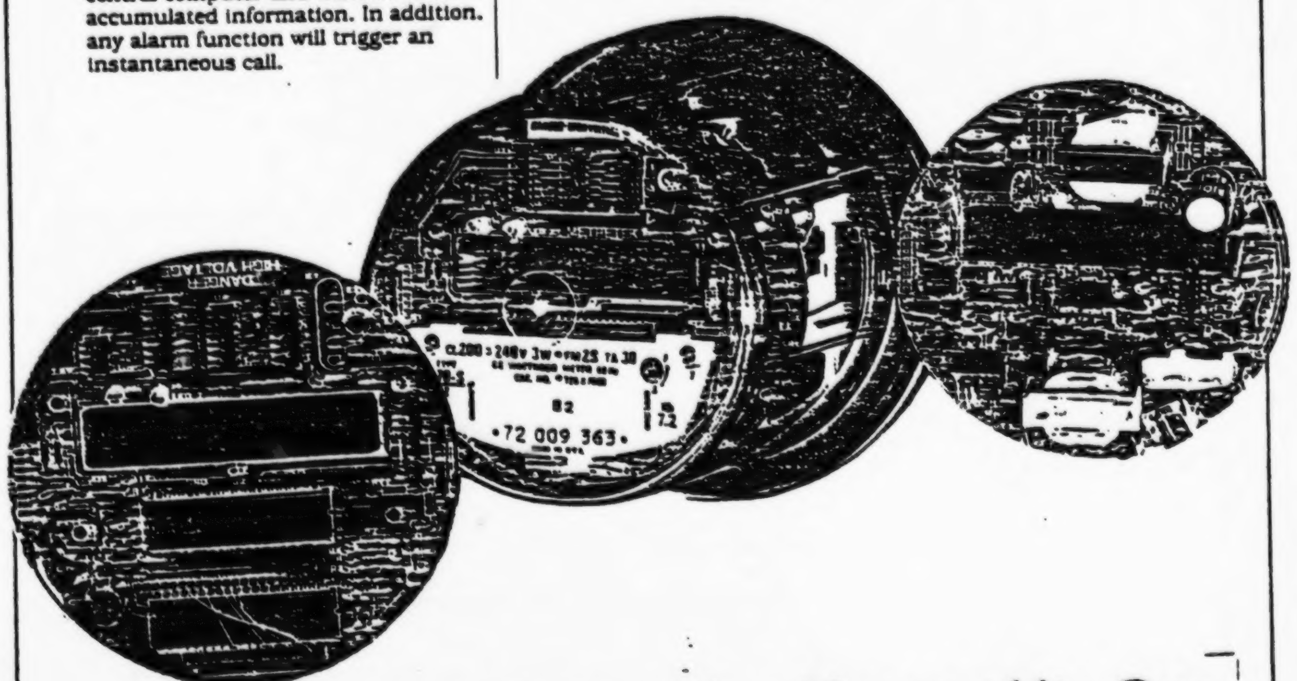
LOAD MANAGEMENT SYSTEMS

Utility Meter Reading

The one with a phone of its own

Metretek developed the Advance Instruction System to provide the utility industry with a reliable, inexpensive, yet practical method of communication between meters at consumer locations and a central utility location. Metretek's Advance Instruction System, or AIS, is a patented system which uses the existing telephone network in a unique way. With the AIS, communications are initiated by the meter rather than interrogation from a central computer. Information is stored in the AIS meter, then, at a preprogrammed time, the AIS calls the central computer and transmits the accumulated information. In addition, any alarm function will trigger an instantaneous call.

Because the AIS is registered with the FCC under Part 68, no phone protection equipment is required, and no telephone exchange modification is necessary. In effect, the telephone company does not get involved in a tariff situation beyond a jack charge and installation. By attaching the AIS meter to the customer's existing telephone line, the utility is provided with a system which is capable of not only automatic meter reading, but also, as many as seven alarm functions and several forms of load management, both voluntary and involuntary.



The One with a Phone of its Own

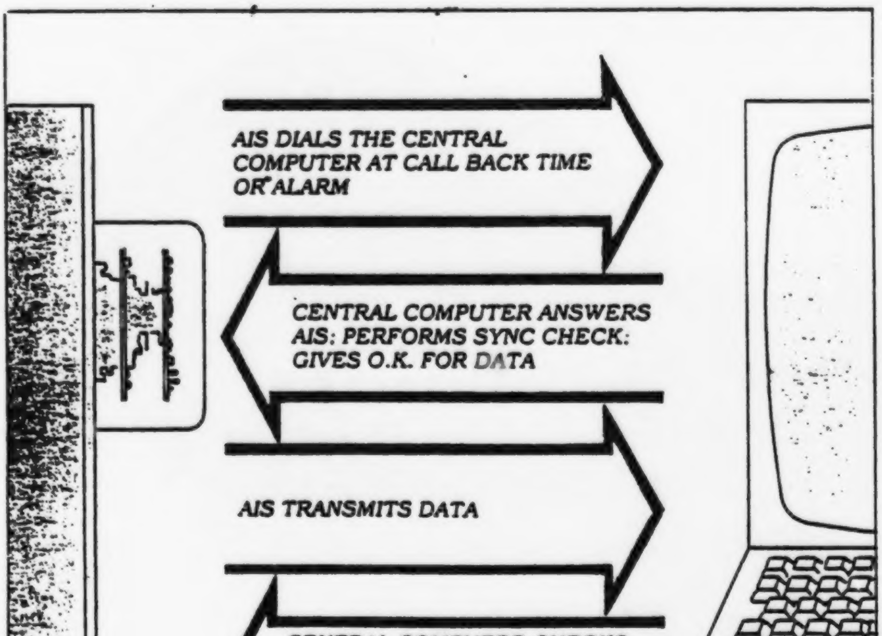
The AIS meter calls the central computer to transmit data via standard phone lines

The AIS data transmission call is triggered by a preprogrammed call back time. The AIS first tests the line. If the line is available, the AIS electronically dials the central computer. The receiver at the central computer answers the call and verifies the identity of the calling point.

If approved, AIS transmits the data, the receiver accepts the data and checks it for accuracy. If the data is accurate, it is stored. If it is unacceptable or incomplete, it hangs up. Whenever a receiver hangs up before a transmission is complete, the point module recognizes the call is incomplete and calls back in four minute cycles.

Once the data is stored in the central computer, the receiver transmits new instructions to the meter. These instructions include synchronizing the real-time clock, setting the new call back time, and any functional changes. These functional changes could include converting from time-of-day meter to demand meter, changing load control parameters, etc.

The AIS employs a very effective data security system with two important functions. The first insures no data is lost or gained during transfer, and guarantees the data received is accurate and meets specified parameters. The second function protects the data from tampering in the event an attempt is made to intercept the data and transmit bogus data.


AIS DIALS THE CENTRAL COMPUTER AT CALL BACK TIME OR ALARM
CENTRAL COMPUTER ANSWERS AIS: PERFORMS SYNC CHECK: GIVES O.K. FOR DATA
AIS TRANSMITS DATA
CENTRAL COMPUTER CHECKS. ACCEPTS DATA: SENDS NEW INSTRUCTIONS: SETS REAL-TIME CLOCK: SETS CALL BACK TIME

Elapsed time: 3 - 5 seconds

AIS offers up to seven alarm functions

If an alarm is triggered, the result is an immediate call to the central computer. Since the AIS is battery powered, the calling capability is not affected by power outage. The extensive range of alarms allows system protection functions such as tampering, gas leakage detection, power outage notification and low pressure notification. It also allows the utility the option to offer life or death safeguard alarms. These could include fire alarms, burglar alarms, medical alert alarms or others.

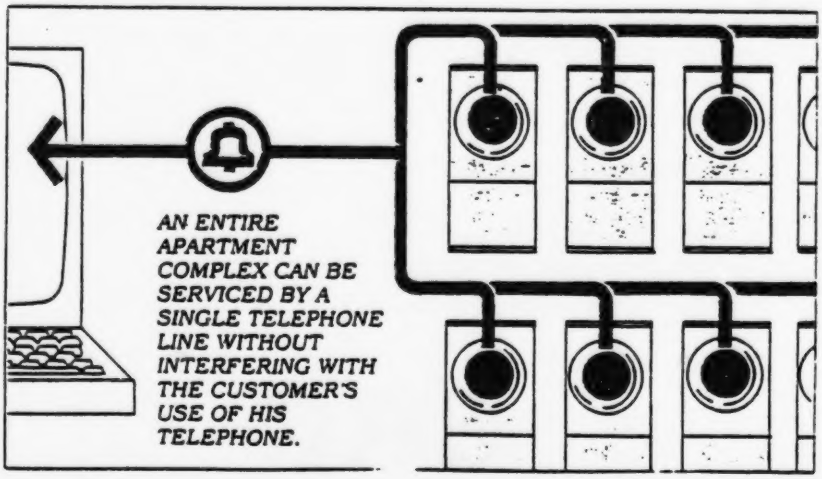
AIS is applicable to electric, gas, or water meters, or any combination

Because the AIS runs on batteries, either non-rechargeable lithiums, or rechargeable Ni-Cads, there is no restriction on the types of meters which can be serviced or their locations. The inherent flexibility of non-rechargeable batteries allows remote meter reading where electric-line power is not available. Examples of this application include reading gas meters or water meters at locations far removed from electric-line power.

When the AIS is used exclusively to collect and transmit consumption data, any two meters can be read with one AIS module. Thus, two electric meters, two gas meters, two water meters, an electric and gas meter, or an electric and water meter, or a water and a gas meter can be read by a single AIS meter with absolute data integrity.

The AIS also offers the utility unusual flexibility in telephone interfacing. Since the AIS presents no ring load to the telephone network, an almost infinite number of AIS modules can be attached to a single phone line. This could result in important economies in an apartment complex since a single phone line in the supervisor's apartment can service the entire building.

Since the standard AIS reporting calls are made during times of low usage, for example, midnight to 6 a.m., the consumer's access to his telephone service will not be affected.

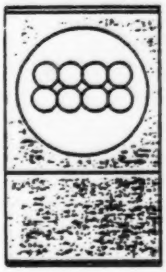


AN ENTIRE APARTMENT COMPLEX CAN BE SERVICED BY A SINGLE TELEPHONE LINE WITHOUT INTERFERING WITH THE CUSTOMER'S USE OF HIS TELEPHONE.

AIS provides both voluntary and involuntary load management

Peak loads constitute a major problem for utilities, with solutions ranging from high priced resources purchased out of system, to the construction of new facilities. AIS offers an alternative to these high cost solutions with the implementation of load management, either voluntary or involuntary.

Time of day metering (voluntary)



This form of load management economically encourages the consumer to defer his optional consumption to a non-peak time by charging high rates for consumption during the utilities peak-demand period. The AIS converts a standard residential meter to a time-of-day meter by storing not only total consumption, but consumption during peak rate periods as well.

Optional display functions are available to notify the consumer that the high rate is in effect, and to display consumption during the peak period of time.

Demand metering (voluntary)

Residential demand metering is an alternative to time-of-day metering with the identical objective. As with time-of-day metering, total consumption is stored for each billing period, however, instead of storing peak consumption, the AIS calculates the highest demand reached during the billing period. This peak demand determines the monthly rate for the metered resource. The optional display can be used to show the customer the highest demand recorded during the recording period.

For Additional Information, Contact:

BROWN BOVERI

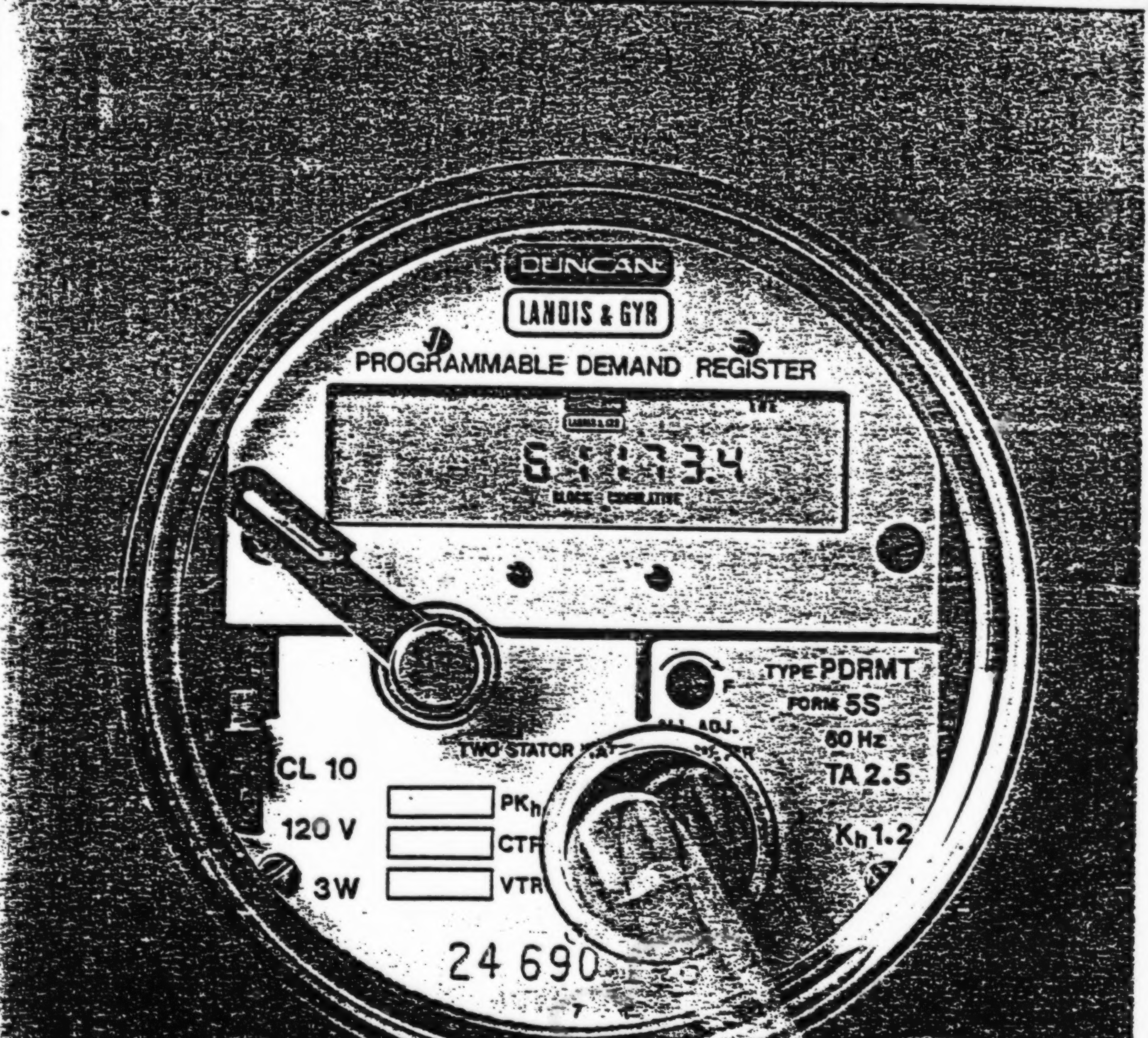
2535 PILOT KNOB ROAD
P.O. BOX 21308
ST. PAUL, MN 55120
(612) 452-9400

265 HYMUS BOULEVARD
POINTE CLAIRE, QUEBEC H9R1G6
(514) 694-6220

4709 BAUM BOULEVARD
PITTSBURGH, PENNSYLVANIA 15213
(412) 622-6200

LANDIS & GYR

Demand Measurement Systems


DUNCAN
LANDIS & GYR
PROGRAMMABLE DEMAND REGISTER
BLOCK CUMULATIVE
TYPE PDRMT
FORM 5S
60 Hz
TA 2.5
K_h 1.2
TWO STATOR
CL 10
120 V
3W
PK
CTR
VTR
24 690

LANDIS & GYR PROVIDES A NEW SOLUTION TO DEMAND MEASUREMENT

Landis & Gyr's Programmable Demand Register (PDR) product family was developed based on the premise that a modern technical solution to demand measurement should offer an electric utility the most flexible and cost effective solution to meeting its particular needs.

Programmable Demand Register

The PDR utilizes solid-state electronic circuitry and can be used with either singlephase or polyphase meters. It has a liquid crystal display that operates over a wide temperature range and can easily be read even in bright sunlight. Twenty-two values are selectable for display, including kwh, present kw demand, maximum kw demand, cumulative kw demand, interval length, and kwh meter constants.

The PDR uses a non-volatile memory that requires no back-up batteries and a photo-optic communications link that permits programming, reading and resetting of the meter without removing the cover.

The PDR permits programming of block or rolling intervals from 1 to 60 minutes, and allows cumulative demand registration. The rolling interval permits increased accuracy of demand measurement because a new interval is started each minute. With the PDR peak splitting is no longer a problem.

Available output options for operating external devices are:

1. Pulse generator including pulse value selection.
2. Customer alert.
3. Load control.
4. End of demand interval indication.

Reading, data retrieval and resetting of the PDR can be performed manually or electronically. When the PDR is read manually, the meter reader scrolls the display to the desired reading by touching the optical port.

Electronic Billing Period Resetters

Electronic Billing Period Resetters give added security and improve meter reading efficiency. All that is required to reset the meter at the end of a billing period is to apply the resetter to the optical port of the PDR and to push a button. The unique user password, which must be recognized by the PDR, insures security.

There are two Billing Period Resetters, the BPR and the BPR-1. Both are inexpensive hand-held electronic devices which use advanced microprocessor design.

The BPR-1 is the simplest version. It resets the demand values after the password has been verified by the PDR's microprocessor. The BPR not only resets the demand values, but also enters the date of reset into the PDR memory from its own internal real time clock.

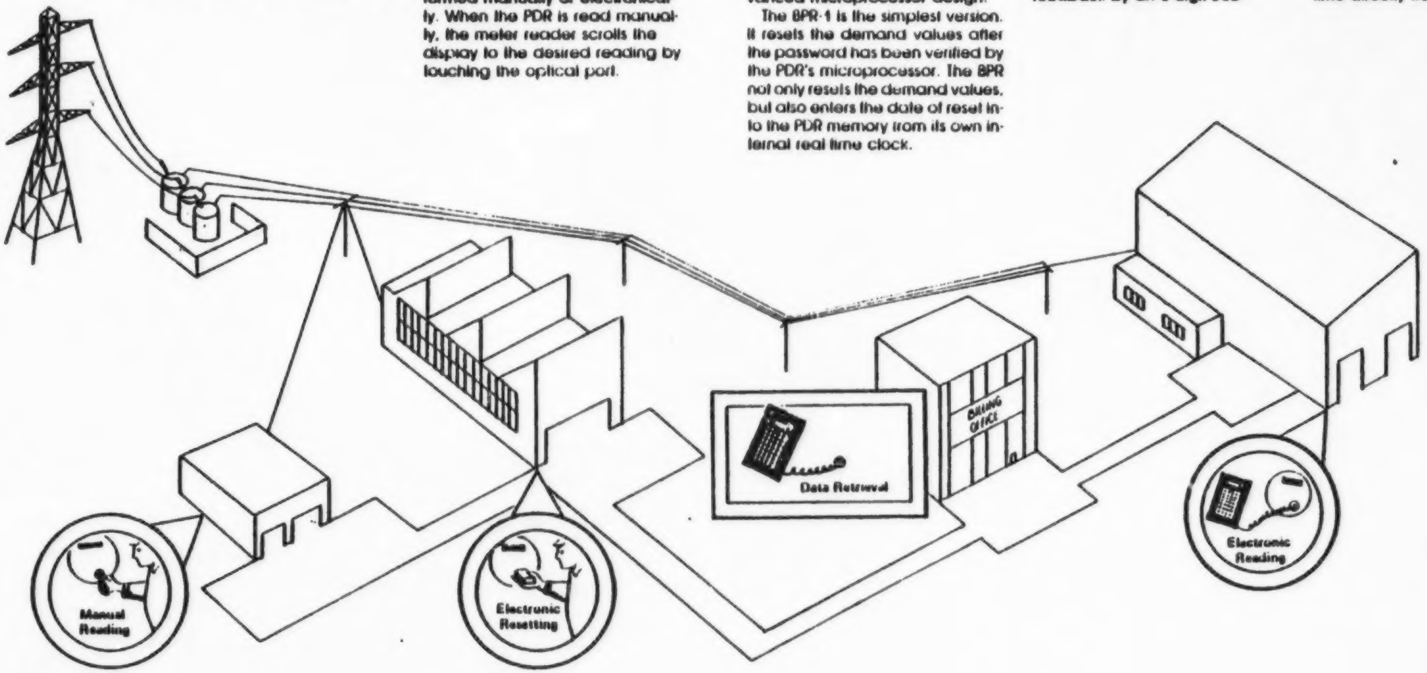
Programmer/Reader

The Programmer/Reader (P/R) is a solid-state, hand-held device for programming and retrieving data from the Programmable Demand Register (PDR). Communication between the P/R and the PDR is through the optical port. An optical pickup on the P/R cable assembly is magnetically held in place on the meter, freeing the operator's hands to perform keyboard operations. A simple-to-use keypad that features clearly defined function keys simplifies programming because it is user-friendly. Visual feedback by an 8-digit LCD display, and an audio tone provide key entry verification.

The P/R gives the utility the option of programming all functions of the PDR in the shop or in the field. A unique user password provides security.

Instant retrieval of PDR information insures accurate and fast reading of demand data. Transcription errors are reduced by electronic processing of the data stored in the PDR.

Billing data may be retrieved from the P/R with the DIS-82 Data Processing Station and other Landis & Gyr translation systems. It may also be retrieved at any time directly from the P/R display.



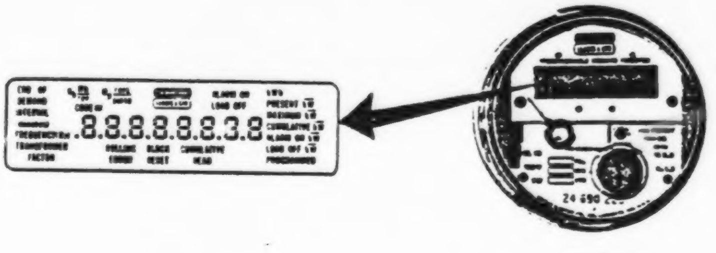
LANDIS & GYR

OFFERS UTILITIES A CHOICE IN DEMAND METERING EQUIPMENT

Electronic Demand Metering

The Programmable Demand Register (PDR) is available on either a singlephase (PDRMS) or polyphase (PDRMT) meter with mechanical reset and may be preprogrammed at the factory as a direct replacement for mechanical demand meters.

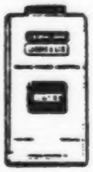
WITH MECHANICAL RESET



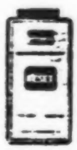
PDRMT

Electronic Resetting

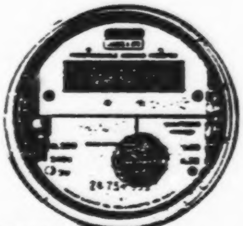
The BPR or BPR-1 can be used to electronically reset the demand values. It operates with both the PDR and the PDR with mechanical reset.



BPR



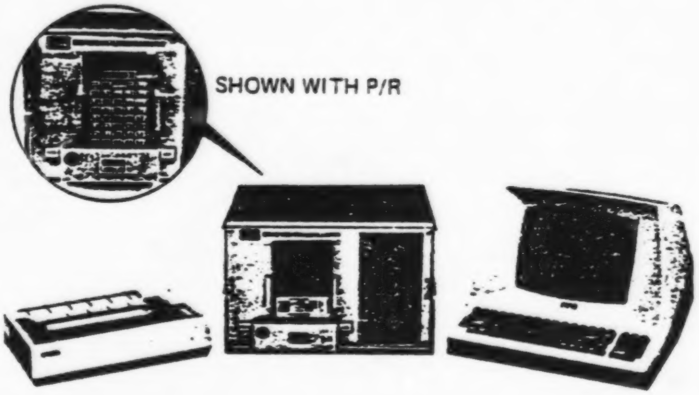
BPR-1



PDRMS

State-of-the-Art Demand Metering

The P/R programs, reads and resets the PDR. The DTS-82 Data Processing Station gives the user the additional capability of data retrieval from the P/R which contains readings from many demand registers. Reports may be displayed on the CRT or printed on a line printer.



SHOWN WITH P/R

DTS-82 DATA PROCESSING STATION

PRINTED IN U.S.A.

DECO2M/6/83

Metering Products

Duncan Electric Co., Inc.
P. O. Box 7180
Lafayette, Indiana 47903
(317) 742-1001 Telex: 27-2120

Corporate Offices

Landis & Gyr, Inc.
4 Westchester Plaza
Elmsford, New York 10523
(914) 592-4400 TWX: 137345

Load Management & Scada

Moore Systems, Inc.
1730 Technology Drive
San Jose, California 95110
(408) 297-9920 TWX: 910 338 0217

PRODUCT SCHEDULE 6C

LANDIS & GYR

DUNCAN
METERING ACCESSORIES

P/F

PROGRAMMER/READE

CAT. SEC. - METERING ACCESSORIES

FOR PRICES, SEE PRICE SCHEDULE 013.

SEPTEMBER 15, 1982
New Issue

PROGRAMMER/READER

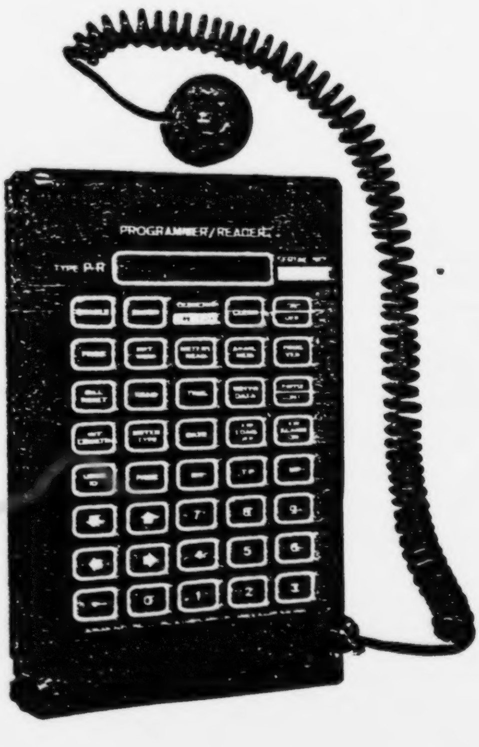
The Programmer/Reader is a solid-state, hand-held device which performs a variety of functions, including programming and retrieving data from the Duncan Programmable Demand Register (PDR).

Billing data is retrieved from the P/R reader with the DTS-82 Data Processing Station and other Duncan. solid-state recorder translation systems.

Communication between the Programmer/Reader and the PDR is achieved through the optical interface at the meter cover. An optical pickup on the P/R cable assembly is magnetically held in place on the meter, freeing the operator's hands to perform keyboard operations. The retractable pickup cable is attached to the P/R through a recessed connector.

Visual feedback relating device operation is provided by an 8-digit LCD display. Additionally, a piezoelectric alarm provides an audio tone for key entry verification.

The P/R uses the same style cases as the ESSDAR Memory Module (EMM) and has a recessed connector for insertion in the Duncan Type MMR reader for translation.



Programmer/Reader, Type P/R, Cat. No. 61978
Carrying Case Cat. No. 62116

SPECIFICATIONS

Supply Voltage	3 AAA Alkaline Batteries
Display	Liquid Crystal Dot Matrix
Keyboard	8 x 5 Touch Switch Matrix
Temperature	0°F to +130°F (Ambient)
Capabilities	Stand-alone Unit or for Use With Duncan Translation Systems
Size	7.43 in L. x 4.68 in. W. x 1.25 in. D
Weight	20 Ounces

PRINTED IN U.S.A.
DECO38c/11/82

DUNCAN ELECTRIC COMPANY, INC. BOX 7180, LAFAYETTE, INDIANA 47903-7180
TELEPHONE: 317+742-1001
A SUBSIDIARY OF LANDIS & GYR, INC.
TELEX: 27-212C

PRODUCT SCHEDULE 600

LANDIS & GYR

DUNCAN
METERING ACCESSORIES

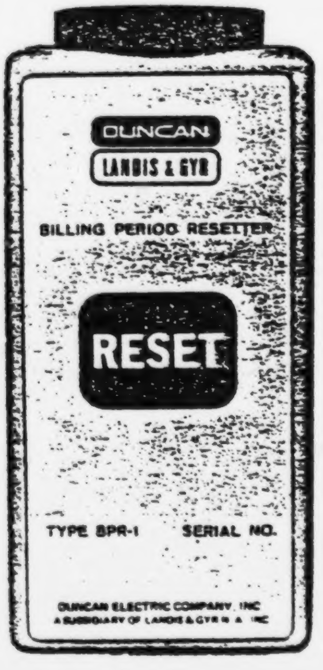
BPR

SOLID-STATE
BILLING PERIOD RESETTERS

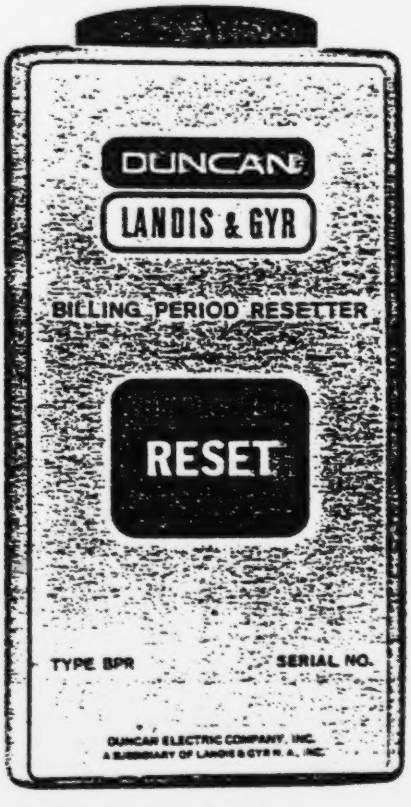
CAT. SEC. - METERING ACCESSORIES

FOR PRICES, SEE PRICE SCHEDULE 013.

FEBRUARY 1, 1984
Supsds. No. 600 3-1-83


DUNCAN
LANDIS & GYR
BILLING PERIOD RESETTER
RESET
TYPE BPR-1
SERIAL NO.
DUNCAN ELECTRIC COMPANY, INC
A SUBSIDIARY OF LANDIS & GYR N. A. INC

TYPE BPR-1
CATALOG NUMBER 61956


DUNCAN
LANDIS & GYR
BILLING PERIOD RESETTER
RESET
TYPE BPR
SERIAL NO.
DUNCAN ELECTRIC COMPANY, INC.
A SUBSIDIARY OF LANDIS & GYR N. A., INC.

TYPE BPR
CATALOG NUMBER 61957

BILLING PERIOD RESETTERS

The BPR and BPR-1 are companion units to the PDR (Programmable Demand Register). The BPR and BPR-1 are inexpensive hand-held electronic devices used to reset the demand register at the end of the billing period.

Using a photo-optic link through the face of the meter cover for demand reset, special emphasis is placed on the security of demand readings. The BPR and BPR-1 resetters contain the user's password which is recognized by the PDR demand register.

The BPR features a real-time clock in addition to the password, and the current date is entered into the PDR demand register's memory at the time of demand reset for security verification.

The BPR-1 is a basic version of the Type BPR Resetter, and is used only for resetting the meter. The date is not entered.

FEATURES

- Advanced microprocessor design
- Small, inexpensive hand-held devices
- User presettable password for reset security

BPR:

- Real-time clock sets date of reset into PDR demand register.
- Uses readily available photo battery. (Duracell 7K67)

BPR-1:

- Most economical of all PDR demand register accessories
- Functions as an electronic key.
- Uses readily available photo battery. (Duracell 7K67)

Billing Period Resetter, Type BPR, Cat. No. 61957
Billing Period Resetter, Type BPR-1, Cat. No. 61956

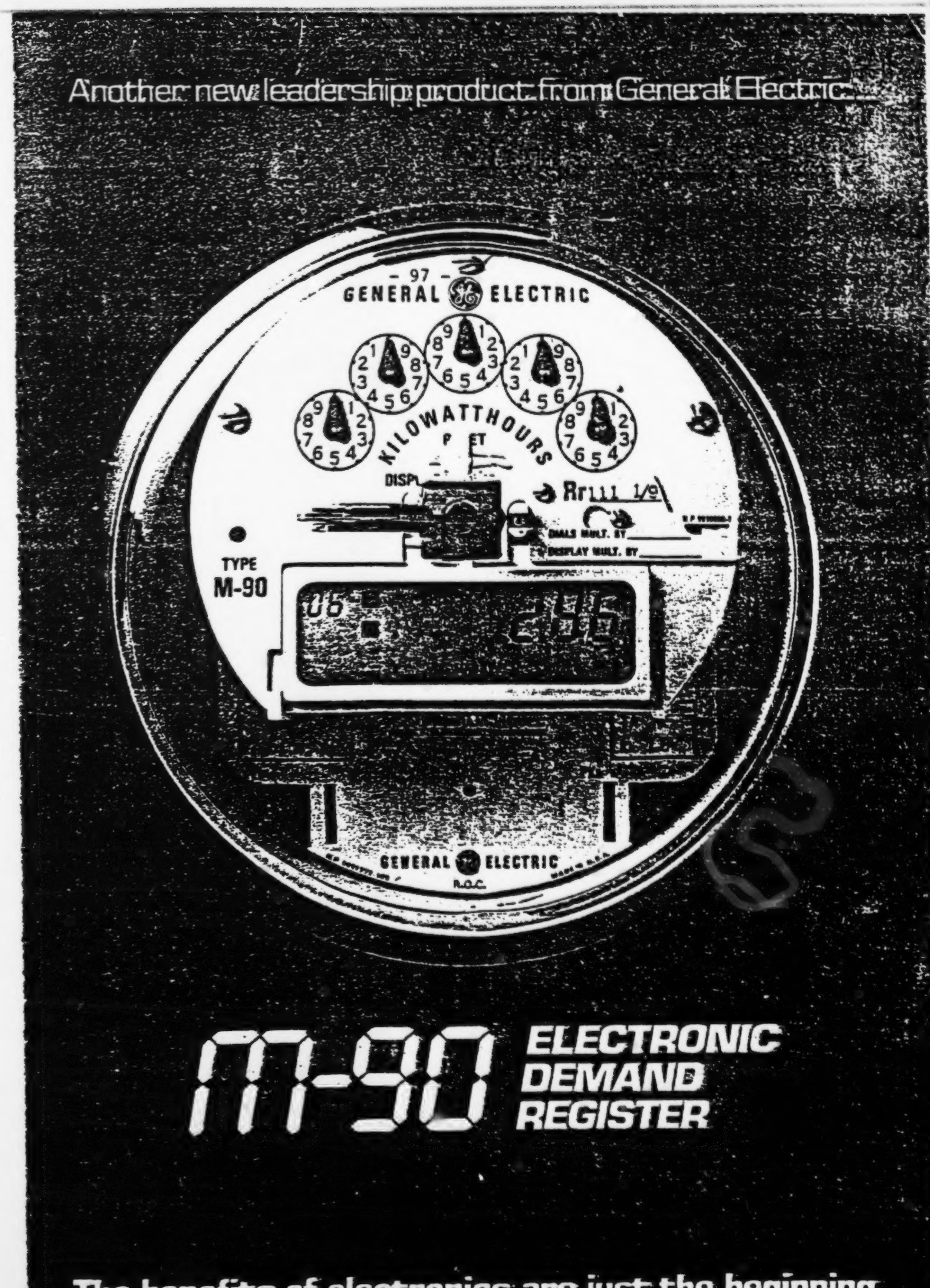
SPECIFICATIONS

	BPR	BPR-1
Power Supply	Duracell Type 7K67 alkaline	Duracell Type 7K67 alkaline
Battery Life	3 months normal usage	1 year under normal usage
Operating Temperature Range*	−30°F to +130°F ambient	−30°F to +130°F ambient
Size	5 in. L x 2.56 in. W x 1.58 in. D	4.25 in. L x 1.97 in. W x 1.312 in. D
Weight	6.5 ounces	3 ounces

PRINTED IN U.S.A.

DECO32c/2/84

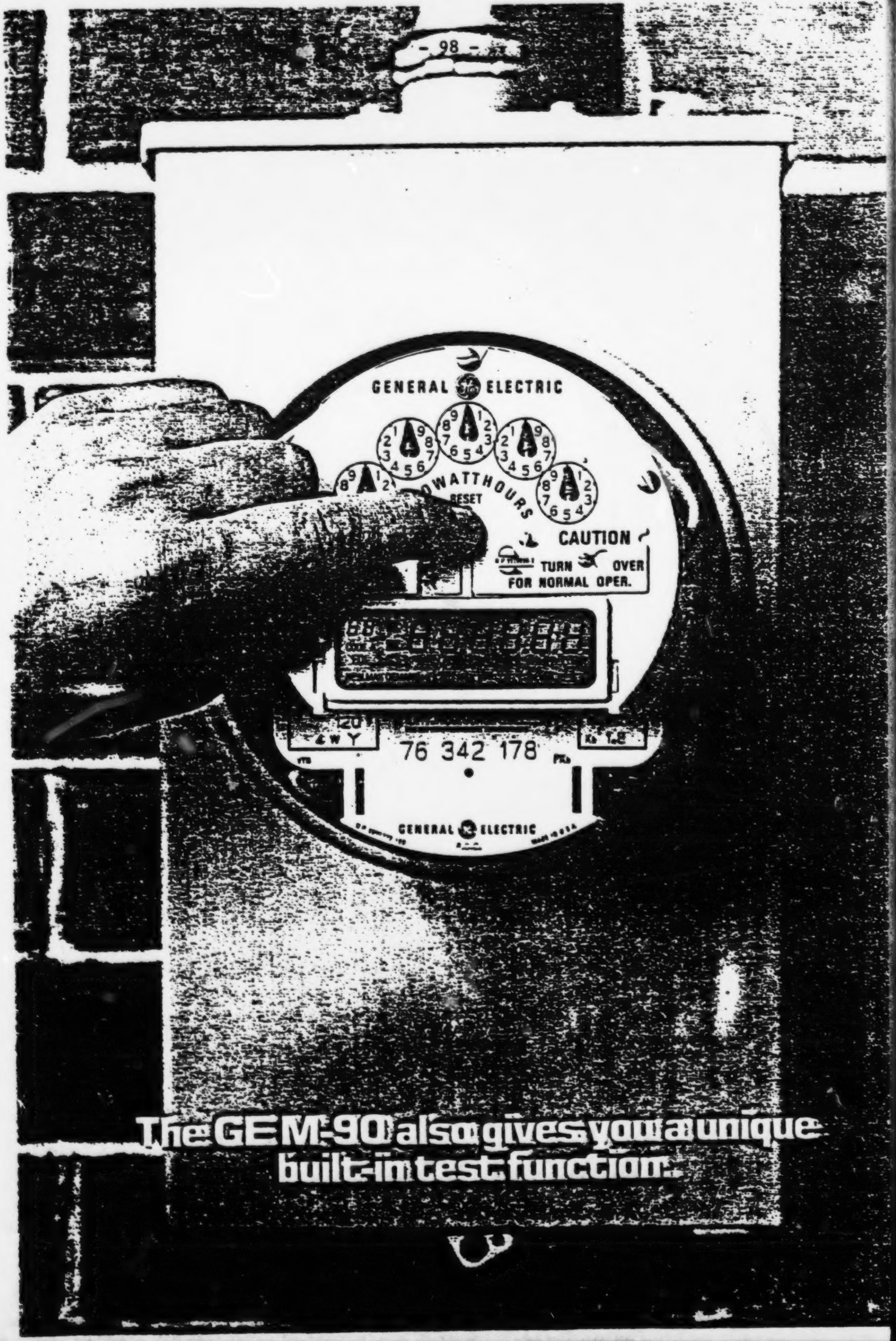
DUNCAN ELECTRIC COMPANY, INC. BOX 7180, LAFAYETTE, INDIANA 47903-7180
TELEPHONE: 317+742-1001
A SUBSIDIARY OF LANDIS & GYR, INC.
TELEX: 27-2120


- 97 -
GENERAL ELECTRIC
KILOWATTHOURS
DISPL
TYPE
M-90
DIALS MULT. BY
DISPLAY MULT. BY
06
246
GENERAL ELECTRIC

Another new leadership product from General Electric

M-90 ELECTRONIC DEMAND REGISTER

The benefits of electronics are just the beginning


GENERAL ELECTRIC
KILOWATTHOURS
RESET
CAUTION
TURN OVER
FOR NORMAL OPER.
76 342 178
GENERAL ELECTRIC
The GEM-90 also gives you a unique
built-in test function.

You'll test conveniently.

The M-90 has a built-in test mode that lets you test it quickly and easily in the field. This not only permits accurate repeatable testing, it also stores billing data during the test cycle and returns it to the register display immediately after the test. That's something no other electronic register can do without the use of special test equipment.

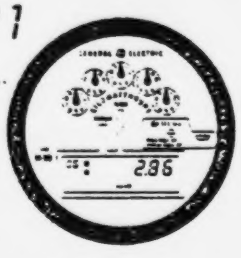
When testing, you can quickly call up each of four quantities for display:

Test Mode Display

- Time remaining in interval
- Present demand (accumulating)
- Maximum demand
- Register input pulse count

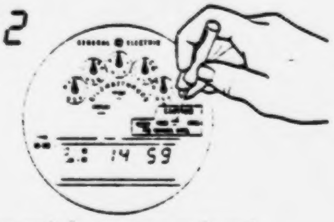
When you want to restart a new test cycle, you simply push the reset switch and all previous test data is erased.

STEP 1



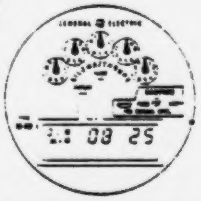
Meter in field as found.

STEP 2



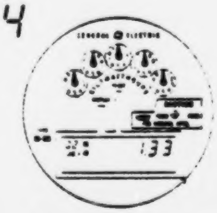
Switch to test mode by turning over the multiplier tab which depresses the test switch. The register begins displaying time remaining in the demand interval (Code #01)

STEP 3



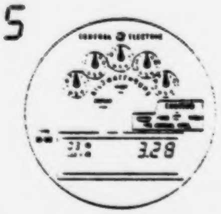
Register continues to display time remaining in the interval. Test can be restarted any time by pressing and releasing the reset switch.

STEP 4



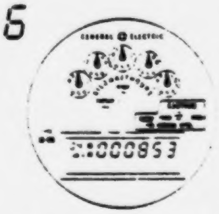
Push and release display switch to Read Accumulating Demand (Code #02).

STEP 5



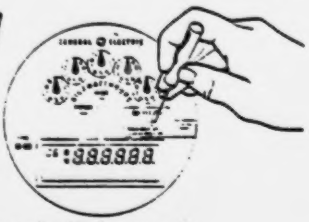
Push and release display switch again to Read Maximum Demand (Code #03).

STEP 6



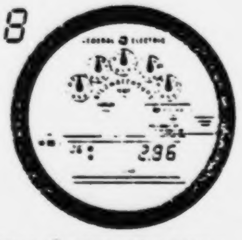
Push and release display switch again to Read Number of Accumulated Pulses (Code #04)

STEP 7



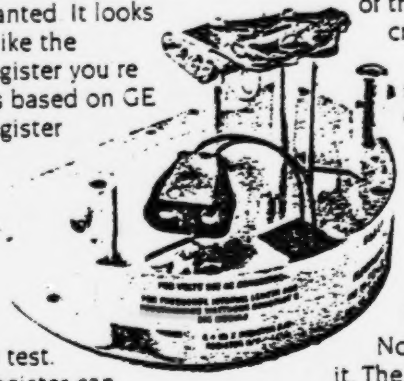
To exit the test mode, simply return the multiplier tab to its original position and the normal display scroll resumes.

STEP 8



Meter operating after test with program constants and billing data intact.

You'll bill more accurately.



Here's the new electronic demand register utilities iike you told us you wanted. It looks and acts just like the mechanical register you're used to, as it's based on GE mechanical register construction. But you'll find it much easier to use, simpler to read and far more convenient to test.

The M-90 register can be programmed to show each billing quantity you need on a liquid crystal display in large, clear digits (the largest available). No accessory equipment is necessary; the meter reader simply records each reading as it appears for seven seconds in automatic sequence.

The normal billing data scroll is fully programmable. What's more, an alternate display sequence lets you verify all programmed constants without using auxiliary equipment. Each item is clearly identified as it appears on the display. (See display scrolls on back cover.)

You have added optional display choices, too: (1) a continuous digital display of minutes remaining in the interval (or subinterval, where rolling demand is being used); (2) a 5-second end-of-interval (EOI) annunciator; and (3) a new maximum demand annunciator that indicates when the stored maximum demand is being exceeded within a given interval.

You select the quantities that are appropriate for your billing data scroll. Then take advantage of the register's increased demand resolution by selecting the demand display format you want from three to six digits with your choice of decimal point position.

Better accuracy? No question about it. The optical system which provides the metering data pulses to the register eliminates demand gearing. And you get positive status verification on the register that those pulses are being received.

You can buy M-90 registers in the same configurations you buy mechanical registers today. They're fully compatible with I-70 single-phase meters, V-60 series polyphase meters, and DS-60 series switchboard meters. Additionally, retrofit registers are available for GE V-60 and DS-60 series meters.

The flexible M-90 provides either conventional block interval or rolling demand calculation with up to six subintervals per interval.

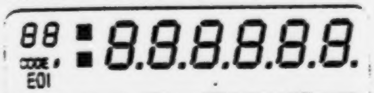
Rolling Demand Capability

Interval Length *(Minutes)*	Number of Subintervals					
	1	2	3	4	5	6
	Subinterval Length *(Minutes)*					
5	5	—	—	—	1	—
15	15	—	5	—	3	—
30	30	15	10	—	6	5
60	60	30	20	15	12	10

Non-volatile memory retains all constants and accumulated billing data during power interruption; thus, no batteries are needed. Time remaining in the current interval is saved so that random interval timing can be maintained, as it is in mechanical registers.

You can program the M-90 register to delay demand measurement after outage from one minute up to 99. The register also displays, upon request, the number of non-volatile memory erase/write cycles (power interruptions) that have been accumulated. Furthermore, it can distinguish between forward and reverse disk rotation and can be programmed to provide an "electronic detent function" by recognizing forward disk rotation only.

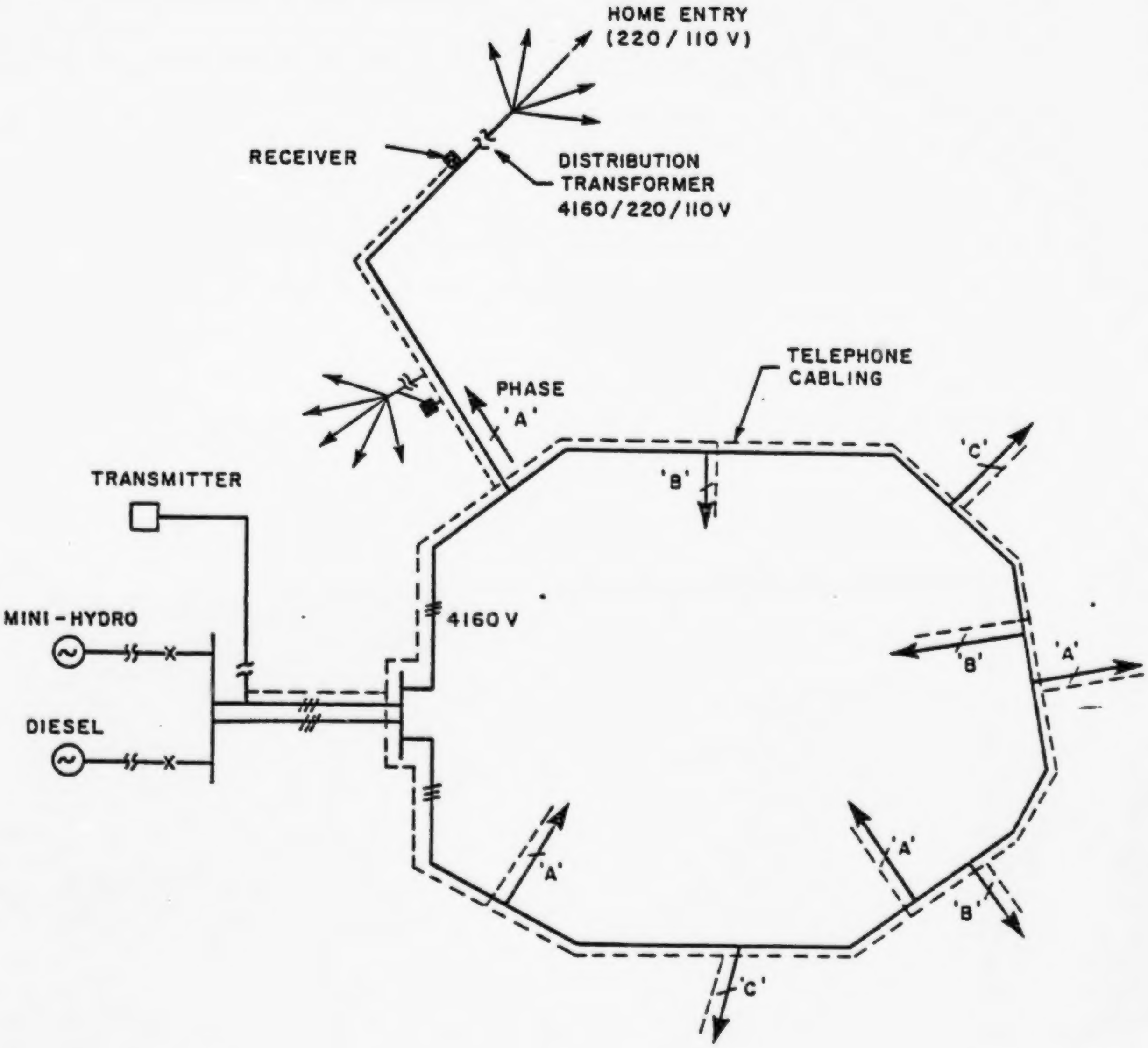
Demand reset at the end of the billing period is initiated simply by operating the reset mechanism in the meter cover. The register immediately displays all segments to confirm that the meter has been reset.



Register display indicates that a demand reset has just been completed by illuminating all display segments.

The cumulative number of demand resets, up to 999, is retained for display in the alternate display scroll and can also be displayed in the billing data scroll.

The register automatically identifies and displays overload conditions if the programmed demand capacity (mechanical register class) is exceeded.


HOME ENTRY
(220/110 V)
RECEIVER
DISTRIBUTION
TRANSFORMER
4160/220/110 V
TELEPHONE
CABLING
PHASE
'A'
TRANSMITTER
MINI-HYDRO
DIESEL
4160 V
'B'
'C'
'B'
'A'
'A'
'A'
'B'
'C'

AUTOMATIC LOAD CONTROL

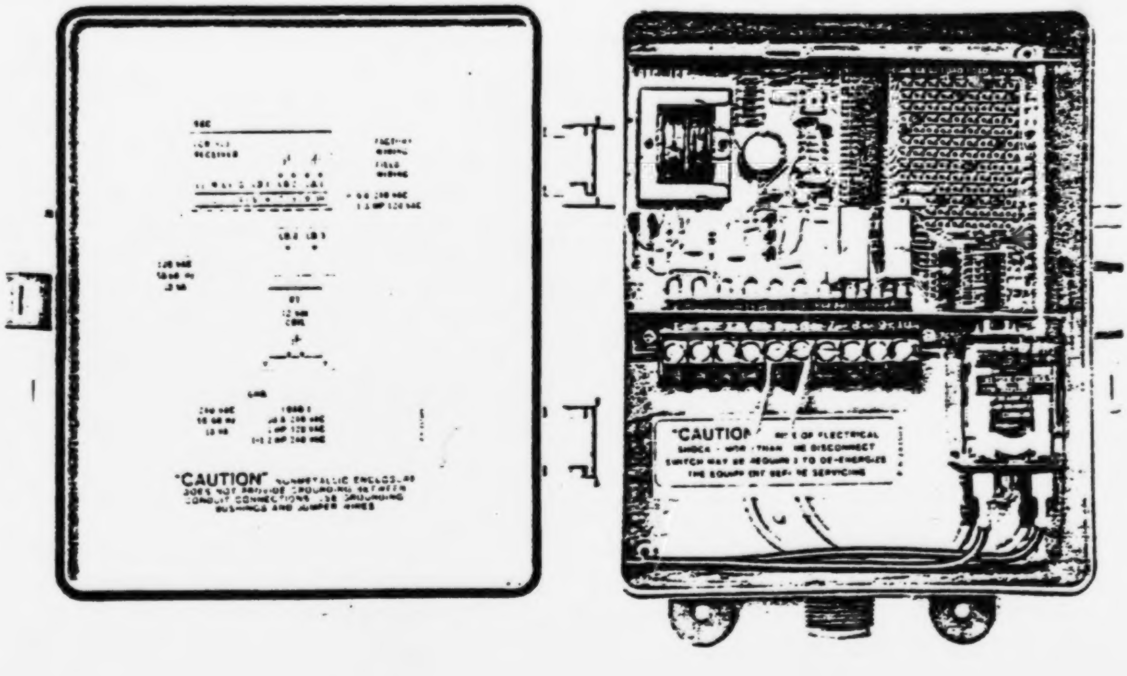
BBC
BROWN BOVERI

LOAD MANAGEMENT SYSTEMS

LOAD CONTROL RECEIVER LCR 500

Standard Features

- Controls One, Two, Three Or More Loads, Independently Or Simultaneously
- Communication By LF Power Line Carrier (Ripple) Or AM Radio
- Compatible With All Major LF Power Line Carrier Message Formats
- Automatic Turn-on Timer For Each Load
- Automatic Cold Load Pick-up
- Integral Operations Counter
- Easy, Economical Installation: Enclosure Includes NEC Wiring Compartment

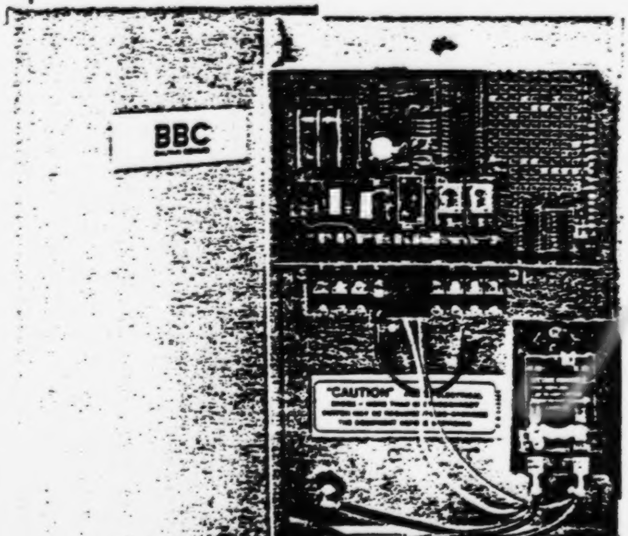


Both the customer wiring and the electronics are housed in a single raintight enclosure. A terminal block is provided for connection to customer loads. The electronics module can be snapped in place after the customer wiring is completed. Standard enclosures meet UL916 requirements, either plastic (shown here) or steel. Other enclosures may be specified.

PUBLICATION NO. LM-103-4/84

Brown Boveri's 30 years of experience in load management systems stands behind the new Load Control Receiver (LCR) Model 500, which represents the fourth generation of BBC solid state receivers. Developed and manufactured in the U.S., the LCR-500 utilizes the most advanced microprocessor technology. Reliability has been improved by the use of simplified circuitry and fewer components. At the same time, the receiver's functional capability has been expanded and the cost reduced.

- One, two, three or more residential, commercial or industrial loads can be controlled by the LCR-500, either singly or simultaneously. The load switches are relays rated 3A or 30A/240VAC (standard) or any other user defined rating. Residential loads include:
  - Water Heaters
  - Air Conditioners
  - Dual Fuel Furnaces
  - Heat Pumps
  - Baseboard Heat
  - Radiant Heat
  - Heat or Cold Storage
  - Meter Registers
- Utility system apparatus such as distribution feeder capacitors, sectionalizing switches and voltage regulators, can be controlled by the LCR-500, resulting in improved system performance.



Wide Range Of Automatic Functions

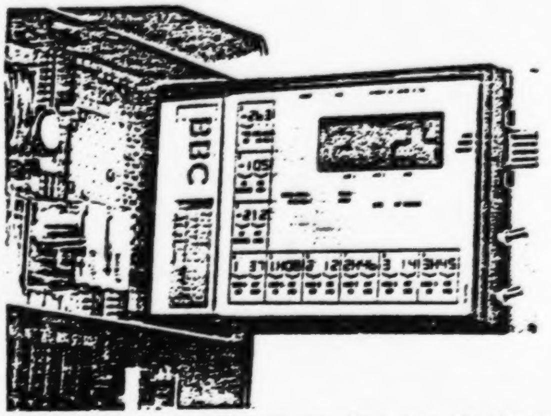
- The LCR-500 allows the utility to select from one of two turn-on operational modes, which are field-adjustable. As an alternative to the full off/on control, the utility can choose the length of off time for each controlled load — either 7, 15, 30 or 60 minutes. A subsequent off command resets and restarts the internal electronic timer. At any time the utility can override the timer with an on command.

  Automatic turn-on by the timer is randomized over a period of ±2 minutes to prevent load surges.
- Cold load pick-up during service restoration is automatically minimized. In a power failure all loads go to the off position. When power is restored the loads will be switched on randomly after 7 ±2 minutes in one minute intervals.
- An integral counter records all off operations for each load.

Communication Options And Message Security

- AM broadcast radio may be used to control the LCR-500, as an alternative to low frequency power line carrier.
- The unit is fully compatible with all major ripple systems, foreign and domestic; all major message formats now in use are integrated into the LCR-500 and are utility-selectable.
- A patented BBC message format makes it possible to sharply reduce the message length, providing fast access to loads. Typical control time is under 7 seconds. In case of emergency all loads can be switched on or off with a single message.
- The coding structure employed in the LCR-500 yields more than 20,000 individual control codes.
- The LCR-500 automatically rejects out-of-tolerance pulses, virtually eliminating false codes from any source and insuring that each switch will respond only to its intended address. A master stop pulse to reset all receivers is used whenever false code pulses are detected by the message security monitor at each injector.

Three Load Control Receiver (1-30 A, 2-3A) in standard sheet metal enclosure with NEC wiring compartment and customized knockouts for easy installation.



The exclusive LTS-560 test set plugs into the electronic module to provide a fast, convenient field check of all major receiver functions.

Quick, Economical Installation

- To facilitate installation, the LCR-500 includes the customer wiring and the electronic module in a single enclosure — there is no need for a separate terminal box for the customer wiring.

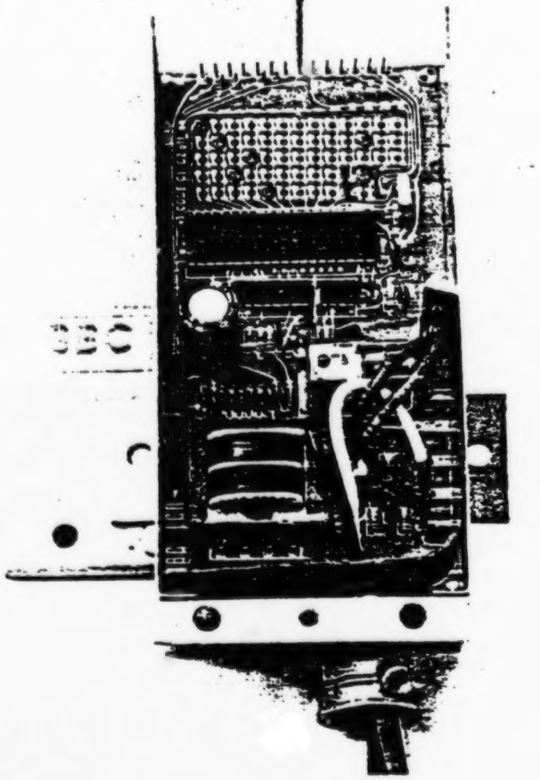
If required, the customer wiring can be completed by the electrical contractor prior to installation of the electronic module. The module snaps into the enclosure in seconds to make the receiver fully operational.

Complete Field Support Equipment

- Checking out the receiver at the time of installation or subsequent trouble-shooting is greatly simplified by Brown Boveri's exclusive LTS-560 test set, a pocket-size panel that plugs into the LCR-500 electronic module. The LTS-560 performs the following functions:
  - Displays the load status of up to three loads individually.
  - Initiates on/off operations for all loads.
  - Verifies and displays the receiver address code.
  - Displays the number of operations on the internal load switch counters.
- As an option, a modified test set, the LTS-570, can be plugged into the electronic module within the case. The digital LCD display can then be viewed through a window in the closed cover.
- Also available for use with the LCR-500 is a portable signal generator that simulates the input signals, and a hand-held signal strenth meter for checking the incoming signal from the utility system.

Total System Capability

- Brown Boveri supplies complete energy management systems. The BBC load management central control units are available in three configurations:
  - Stand-alone systems with single or fully redundant CPUs.
  - Stand-alone systems with SCADA/EMS interface.
  - Load management control integral with SCADA/EMS computer system.
- In addition to complete hardware, designed and manufactured in the U.S., BBC performs studies and provides all required engineering support, assuring single-source responsibility for load management or total energy management systems.

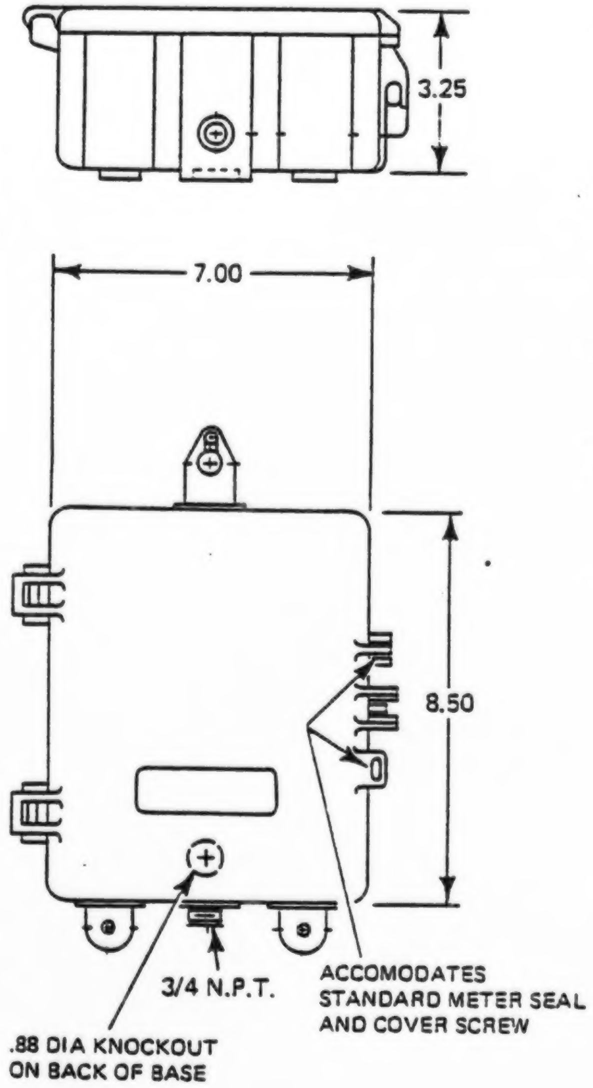


Single Load Control Receiver (1-3 A) in compact 7" x 3" x 2" sheet metal enclosure with lead wires and customized conduit connector for installation directly at the controlled load.

BBC
BROWN BOVERI

STANDARD SPECIFICATION

Dimensions



Weatherproof Enclosure	Injection molded plastic (standard) Sheet metal (standard)
Number of Load Switches	One, two, three or six relays per receiver (standard)
Load Switch Ratings	3A or 30A/240 VAC, normally closed in any combination (standard)
Input Voltage	120 and 208/240 VAC (standard) 24 and 480 VAC (optional)
Automatic Turn-on Timer	7, 15, 30 and 60 min. for each load, field selectable (standard)
Cold Load Pick-up	7 ± 2 min. (standard)
Operations Counter	Individual counter for each load (standard)
NEC Wiring Compartment	Included in receiver enclosure (standard for receiver models A, C, D, E)

For Additional Information, Contact:

BBC
BROWN BOVERI

© BROWN BOVERI

2535 PILOT KNOB ROAD
P.O. BOX 21308
ST. PAUL, MN 55120
(612) 452-9400

265 HYMUS BOULEVARD
POINTE CLAIRE, QUEBEC H9R1G6
(514) 694-6220

4709 BAUM BOULEVARD
PITTSBURGH, PENNSYLVANIA 15213
(412) 622-6200

BBC
BROWN BOVERI
LOAD MANAGEMENT SYSTEMS

LOAD MANAGEMENT SYSTEM

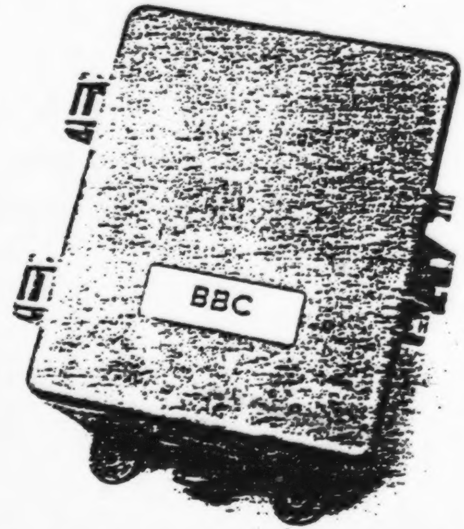
Standard Features

- Automatic reduction of peak demand by cycling residential loads such as water heaters, air conditioners, baseboard heaters, etc., or industrial loads.
- Increase of off-peak load by control of dual fuel heating (oil and electric) and heat or cold storage units.
- Reduction of system losses and service restoration time by controlling power factor, system voltage and cold load in-rush.
- Increase of overall system performance by controlling power system apparatus utilizing the integral Supervisory Control and Data Acquisition (SCADA) functions.
- Communication between centrally located master station and large numbers of remotely installed receivers by highly secure power line carrier or economical AM broadcast radio.
- Support of advanced functions such as remote meter reading, demand subscription service and distribution automation.

Standard System Components Include:

- Computer-based Master Control Unit (MCU)
- Communication link between MCU and substations or radio transmitters
- Substation Injection Units (SIU) for power line carrier communication
- Local Modulation (LMU) for AM broadcast radio communication
- Load Control Receivers (LCR)

Master Control Unit in Desk Console with Color CRT, High Speed Printer and Disk Drive.



Load Control Receiver in weatherproof Injection Molded Plastic Enclosure with One, Two or Three Load Switches.

PUBLICATION NO. LM-102-9/83

1. SYSTEM FUNCTIONS

Direct Load Control

The Master Control Unit (MCU) automatically or manually initiates control commands to control remotely installed receivers. The receivers may be installed in residencies, industrial plants, or other locations, and individually control one two, three or more loads, such as:

- electric water heaters
- air conditioning units
- baseboard heaters
- heat pumps
- radiant heaters
- dual fuel furnaces
- heat or cold storage units
- meter registers
- industrial loads

The controlled loads are categorized in user defined load types and load groups. The standard system configuration yields 31 load types divided into 48 load groups each, totalling 1,488 individual load groups.

The MCU automatically sheds and restores load groups by comparing the actual system load with predefined load control setpoint levels, demand input to the MCU from host SCADA system or real-time KW data acquired from substations. Optional historic data processing produces graphic displays of load curves, etc.

Load groups can also be controlled ON or OFF according to timetables, external digital contact closure or directly from host computers. The operator can, at any time, manually shed or restore load groups. Broadcast commands like "all water heaters OFF", "all heat pumps OFF" and "all loads OFF", are user defined.

An optional load research software module automatically logs the load reduction resulting from controlling a load group OFF. The optional historic data processing module automatically logs load shed activities (load group ON/OFF times and number of sheds) on a daily and monthly basis.

The MCU automatically enforces user defined minimum ON and maximum OFF times for each load group in order to minimize customer discomfort. Only in cases of emergencies are loads controlled OFF as long as necessary.

Power Factor Control

Similar to directly controlling residential loads, the MCU supports control of distribution feeder devices, e.g. switched capacitors or reactors. Control receivers, located on distribution feeders, control power factor correcting capacitors ON or OFF as directed by the MCU. The MCU determines, by monitoring feeder VAR flow, which capacitor bank to connect or to disconnect. Implementation of this function is only recommended for systems utilizing power line carrier communications because of reliability requirements.

Data Acquisition

Status, alarm and data (analog and pulses) points can be monitored by the optional data acquisition software package. The information from each remote site is telemetered to the MCU via existing communication channels.

The telemetered information is displayed on the CRT. Alarm limits can be specified for each data point: change alarm for status and alarm points, low and high level alarms for data points.

The minimum load management system configuration includes the monitoring of one (1) data point, i.e., KW per Substation Injection Unit (analog or pulse).

Additional data monitoring points can be implemented if required.

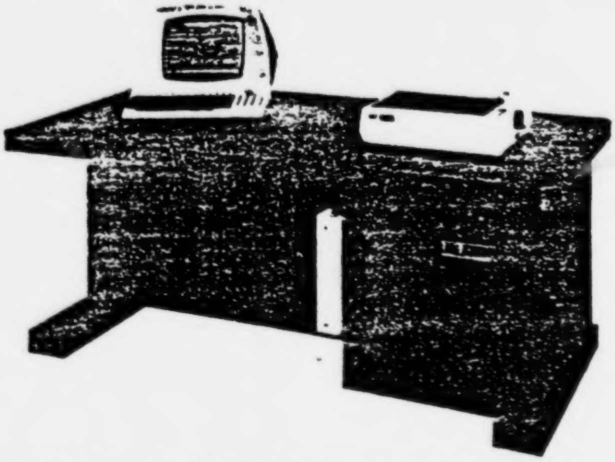
Supervisory Control

The standard supervisory control software package enables the user to control apparatus in substations with SIU's. For control in substations without SIU's stand alone Remote Terminal Unit (RTU) will be installed. Associated status points may be monitored to verify proper execution of control actions.

Future Expansion

The system may be expanded in the future to accomplish the following tasks:

- Add-on SCADA Remote Terminal Units
- Integrated SCADA/Load Management/ Distribution Automation functions
- Integrated Accounting Software
- Demand Subscription Service
- Load Survey Data Acquisition
- Time-of-Day Metering
- Automatic Remote Meter Reading



Master Control Unit in Desk Console with Black and White CRT and Standard Line Printer.

2. MASTER CONTROL UNIT

The Master Control Unit (MCU) is a microprocessor-based central control station, expandable to up to 512 KB memory. It accomplishes all tasks as described above and allows future installation of optional software packages and new Substation Injection Units without major hardware and software additions.

Master Control Unit Hardware

The MCU consists of:

- System Controller with up to 512 KB memory
- Telemetry Master Terminal with Modem
- Black and White or Color CRT Terminal with full ASCII Keyboard
- Dot Matrix Printer
- Floppy Disk Drive
- Battery Back-up
- Desk Console
- Interface to Host Computer (e.g. RS232)

All software programs are stored in non-volatile EPROM, immune to operator CRT/keyboard entries. User defined data are permanently stored on floppy disk or in static RAM memory.

After power outages, the MCU reconfigures itself by automatically loading the user defined system data from floppy disk or static RAM and enabling all peripherals.

Critical system alarms are indicated by an audible device. Should the system controller (CPU) itself fail, the audible device is activated as well.

The battery back-up allows MCU operation for approximately 4 hours in case of power failure. This includes system controller, telemetry master terminal and floppy disk drive. Only A/C powered peripherals such as CRT and printer are not functional during power outages.

Master Control Unit Software

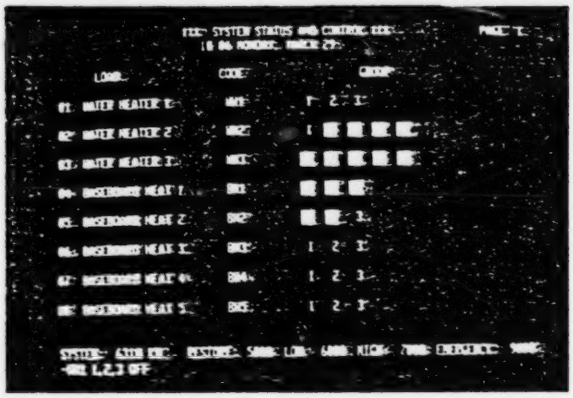
Operator Control Processing

The operator can manually shed/restore any load by typing in the control code (e.g., WH 1), one or more load groups (e.g., 1, 2, 3) and the control action (e.g., OFF). Upon pushing the RETURN key, a single load control message is transmitted via the Substation Injection Units throughout the power system and all WATER HEATER 1 load groups are shed simultaneously.

Manual commands include SCRAM commands like ALL OFF and ALL ON.

The SYSTEM STATUS AND CONTROL display shows on a single page (examples in parentheses):

- LOAD types (WATER HEATERS 1)
- Control CODE for manual control (WH 1)
- Load GROUPS per load type (1, 2, 3)
- Status of all load groups:
  ON=group number in Normal Video
  OFF=group number in Reverse Video
- Accumulated SYSTEM load (6310 KW)
- RESTORE load control setpoint (5000 KW)
- LOW load control setpoint (6000 KW)
- HIGH load control setpoint (7000 KW)
- EMERGENCY load control setpoint (9000 KW)



System Status and Control Display showing the status, of all load groups actual system load and all load control setpoints.

Automatic Load Control

The MCU automatically sheds load groups in a predefined STRATEGY when the SYSTEM load, accumulated from all connected substations, exceeds the user defined LOW load control setpoint. The pace, at which load groups are shed, doubles when the system load exceeds the HIGH load control setpoint.

All load groups are cycled, i.e., they are automatically restored when their MAX. OFF time, defined in the CONTROL COMMAND DEFINITIONS display, has been reached. Once restored, load groups can only be shed again if their user defined MIN. ON time has been reached.

Should the SYSTEM load, however, exceed the EMERGENCY load control setpoint, the MIN. ON/OFF MAX. OFF time mechanism is temporarily disabled to allow reduction of extreme peaks with limited customer discomfort.

If the SYSTEM load drops below the RESTORE load control setpoint before the MAX. OFF of one or more load groups has been reached, these groups are automatically restored by the MCU on a first OFF/first ON basis.

The automatic load control software sheds only load groups which are ENABLED for load control by the operator.

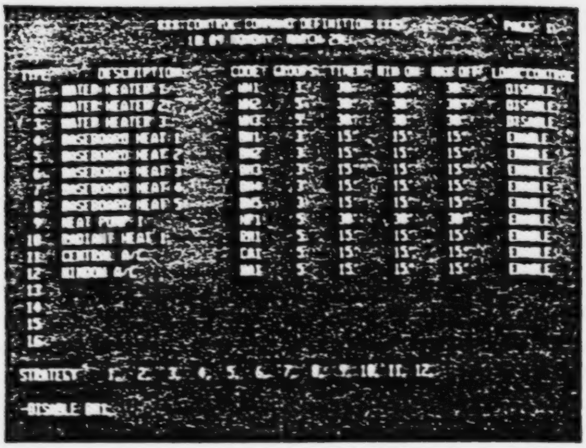
Event and Alarm Logging

All events and alarms are recorded on the printer, showing time and date of the event or alarm. Separate EVENT and ALARM logs are kept in the MCU, which can be displayed upon operator request.

Alarm Processing

The MCU software distinguishes between critical and noncritical alarms. Should a critical alarm occur, an audible device is turned on and the ALARM log summary is automatically displayed, showing the most recent alarm on the top of the display page. The operator has to acknowledge critical alarms by typing SILENCE. The system then automatically returns to the previously active mode of operation.

A total of twelve (12) alarms/status points are telemetered back from each Substation Injection Unit (SIU) or Local Modulation Unit (LMU).



The Control Command Definition Displays shows all user defined load type names, control codes, load group cycle times, load control STRATEGY and whether a load type is currently ENABLED or DISABLED for load control.

Optional Load Control Software

Optional software modules include timetable processing, external event processing, system load bargraph displays, load research packages, etc. as described in Section 1, "Systems Functions."

Supervisory Control and Data Acquisition

Brown Boveri Load Management systems utilize standard SCADA hardware and communication protocols to establish secure communication links between MCU and SIU. The standard system returns up to sixty (60) status/alarms or five (5) data points (analog or pulse inputs) from each SIU.

Additional Remote Terminal Units (RTU) at the same or other substations may be installed to accomodate increased requirements for SCADA functions.

The monitored status/data points can be associated with user defined alarms, e.g., status change, low/high level alarms, etc. Additional SCADA functions can be implemented upon request.

3. TELEMETRY SYSTEM

A microprocessor based telemetry subsystem is employed to communicate between MCU, Substation Injection Units (SIU), AM radio Local Modulation Units (LMU) and individual Remote Terminal Units (RTU).

A single telemetry master terminal can communicate with up to 98 SIU/LMU/RTU over dedicated or party lines.

A total of eighteen (standard configuration: nine) 12-bit words can be sent from each remote to the master and up to two 12-bit words can be received by each remote. Each 12-bit word can either represent 12 discrete status or alarm points, or one data input (analog or pulses), converted into a 3-digit 12-bit BCD signal. The telemetry capacity of the system is only partially used for standard load control system features. The remainder of inputs and outputs at each SIU or LMU may be used for SCADA purposes.

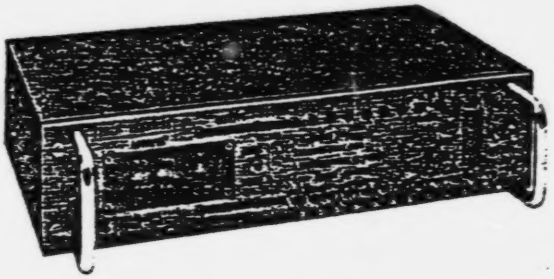
Communications can be established over pilot wires, unconditioned half-duplex Bell 3002 telephone lines, microwave, power line carrier or two-way VHF radio.

The message protocol features CRC (Cyclical Redundancy Code) which detects multi-bit errors and corrects single bit errors.

A Select-Check-Execute control sequence is utilized as a standard communication means in order to achieve maximum data security, in addition to the high resolution CRC encoding.

Should a communication attempt not be successful after three consecutive times, a DATA FAIL alarm is initiated for a particular data word. The remainder of the message or the other RTU's are not affected by a DATA FAIL alarm.

The standard data rate is 300 baud for maximum communications reliability with options for 600 and 1200 baud.



A unique microprocessor based Telemetry System Test Set is available, which simulates either master or remote for complete system readout and verification. It allows one operator at one location to checkout every SIU and RTU in the system and verify its operational availability.

---

4. LOAD CONTROL COMMUNICATION TECHNIQUE

Two alternate techniques are available to communicate between central location(s) and large numbers of remotely installed Load Control Receivers (LCR):

- Low frequency (LF) power line carrier using the utility owned and maintained transmission and/or distribution system for highly secure communication requirements.
- Commercial AM broadcast radio stations for most economic (initial) system implementation.

The modulation technique employed for both systems is simple and proven time multiplex amplitude shift keying (ASK). The AM broadcast radio system may, at any time, be converted to power line carrier without exchanging the Load control Receivers.

4.1 LF Power Line Carrier Communication

Power line carrier signals are generated by one or more Substation Injection Units (SIU). The SIU is a self-contained unit suitable for outdoor installation in transmission or distribution substations. Upon receipt of a digital message from the MCU, the SIU converts the message into a load control command, keys the signal frequency generator accordingly and transmits the control command via the coupling circuit into the power system.

SIU's are available for signal injection into 69, 115, 138, or 161 KV transmission systems and/or into 4.2, 13.8, 23, and 34.5 KV distribution/subtransmission systems.

Carrier frequencies are carefully selected by Brown Boveri during system design and range from 200 to 500 Hz. Frequencies in this range ensure maximum signal propagation and do not require power system conditioning, such as installation of transformer bypasses and capacitors traps. No interference with other apparatus has to be expected.

The signal generator is a forced commutated SCR converter, proven in more than 500 systems worldwide. Brown Boveri Substation Injection Units are available with neutral/ground, parallel and series coupling circuits for all of the above referenced injection levels.

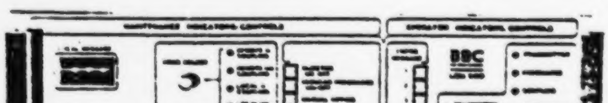
Substation Injection Unit in outdoor enclosure complete with:

- **Local Control Unit**
- **Signal Generator**
- **Coupling Circuit**
- **Protective Equipment**

4.2 Local Control Unit

Each SIU is equipped with a microprocessor controller, the Local Control Unit (LCU). The LCU includes the following features:

- Storage of up to 1488 load control commands.
- Storage of five predefined emergency messages including ALL OFF and ALL ON.
- Generation of load control messages.
- Verification of all transmitted load control messages and automatic repetion in case of incomplete messages.
- Communication with MCU via standard SCADA Remote Terminal Unit.
- Manual control by means of simple pushbutton/thumbwheel switch without use of any test equipment.
- Display of SIU status, mode and alarms by individual LED's.
- Test set available as simply back-up in case of LCU failure.



Local Control Unit front panel with status/alarm indicators and keys for mode select (remote/local), test programs and initiation of local and emergency messages.

4.3 AM Broadcast Radio

For control of load control receivers utilizing AM broadcast radio, a Local Modulation Unit (LMU) is installed at an existing commercial AM broadcast radio station. Communication with a centrally located Master Control Unit is identical to PLC equipment (SIU) as described above.

The LMU includes a Local Control Unit with most of the functions described in 4.2. The control signal is a subaudible 20 to 28 Hz tone frequency which is inserted into the broadcast station's audio line on top of the regular program material.

Signal frequency and modulation level (typically 5%) are within FCC limits. Negative or positive overmodulation is avoided by existing signal processors downstream from the point of signal insertion.

The advantage of AM broadcast radio over other types of radio control is that signal propagation is more accurately predictable, resulting in more reliable overall system performance. Furthermore, a single AM broadcast radio station may cover a very large area. Typically, the area within the 2mV/m field strength contour line can be considered as the control area. Multiple AM transmitter schemes are supported.

In addition to the standard Local Control Unit (LCU) functions, the LMU includes an indicator/alarm panel with the following features:

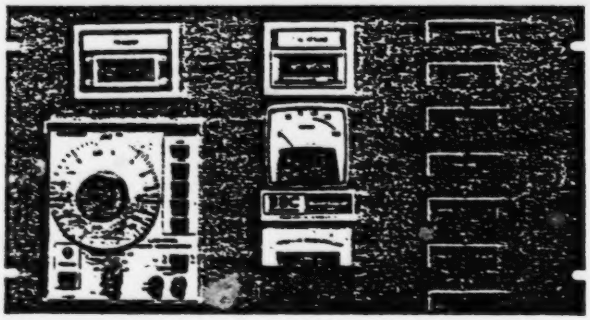
Display/Control

- Output Frequency (Hz)
- Signal Modulation Index (%)
- Total Modulation Index (%)
- "Panic" Switch

Setpoints/Functions

- Low Alarm/High Alarm Output Frequency
- High Alarm Output Signal Modulation Index
- High Alarm Total Modulation Index
- Emergency Disconnect of Transmitter Audio Line

Occurrence of any alarm will immediately abort the current message transmission and will be indicated by an audible alarm and via telemetry to the Master Control Unit. Each alarm requires an individual operator acknowledgement and manual or remote LMU restart to ensure clearance of alarm conditions.



Local Modulation Unit for signal generation, equipment monitoring and operation verification at AM broadcast radio stations.

Typical output impedance of the LMU is 600 Ohms. Other impedances may be specified.

An optional printer may be connected to the LMU for time-tagged hard copy printout of all control activities and alarm occurances at the radio station.

Each load control command stored at the LMU may also be initiated by digital contact closure. This feature could be utilized to control remote portions of a utility service area without a dedicated telephone line to that particular radio station.

5. Load Control Receivers

Brown Boveri's standard Load Control Receivers controls one, two, three or more loads individually or simultaneously. Standard load switch ratings are 3A/240 VAC and 30A/240 VAC. Other ratings may be specified. The 3A and 30A load switches can be specified in various combinations for each individual control receiver.

Standard Features

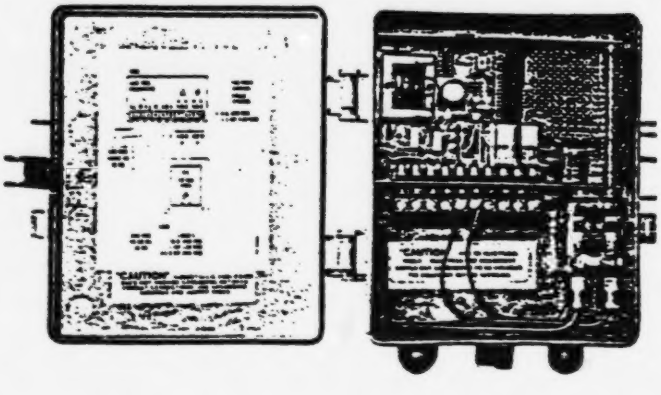
- Up to 20,000 individual addresses.
- Up to four user selectable automatic turn-ON times (7, 15, 30 or 60 minutes) for each load or individual ON/OFF control from the MCU.
- Cold load pick-up: all loads are turned OFF after power outage and restored randomly after 7 ± 2 minutes to support service restoration.
- Integral operations counter: a three digit counter keeps track of all OFF operations performed by each controlled load.
- High communications security: the LCR checks the OFF times between message bits for absence of control signal. If a too high signal level is detected (e.g., noise) the receiver aborts message evaluation and resets.
- Dual voltage power supply: terminals are supplied for 120V and 208/240V input voltages, thus eliminating the need to store receivers for different applications.
- Pocket-sized test set for complete receiver checkout and verification of relay functions, including the wiring to controlled loads.
- Various message formats user selectable.
- Designed to satisfy UL 916.
- Communication with central location(s) via power line carrier (LCR 500/600 Series) or AM broadcast radio and power line carrier (LCR 100/200 Series). Conversion from AM Radio to PLC without replacement of receiver.
- Load Control Receivers with greatly expanded functions (LCR 200/600 Series) are available.
- Applications such as meter register switching, automatic meter reading and demand subscriptions service (DSS) are supported.

Installation

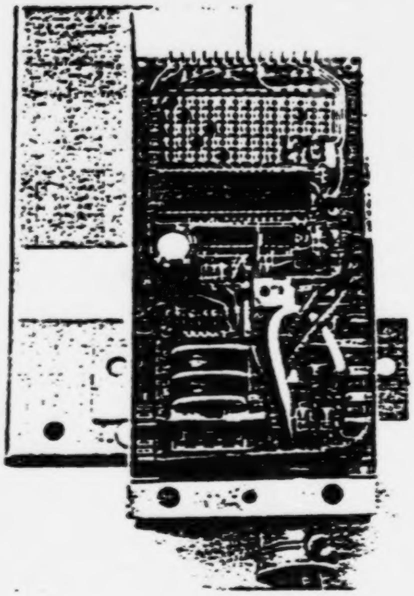
The LCR 500/600 is available in standard injection molded high impact plastic and sheet metal (sheet metal enclosures are not available for AM radio receivers) enclosures with standard or customized knockouts. All encosures are weatherproof and suitable for outdoor installation.

Each enclosure contains the electronic receiver module and an NEC wiring compartment (except in LCR 511F as shown on the following page). The electronic module can be snapped in and out in seconds without the use of tools. The NEC wiring space provides room for connecting the house wiring to receiver terminals/relay contacts. There is no need for an additional junction box.

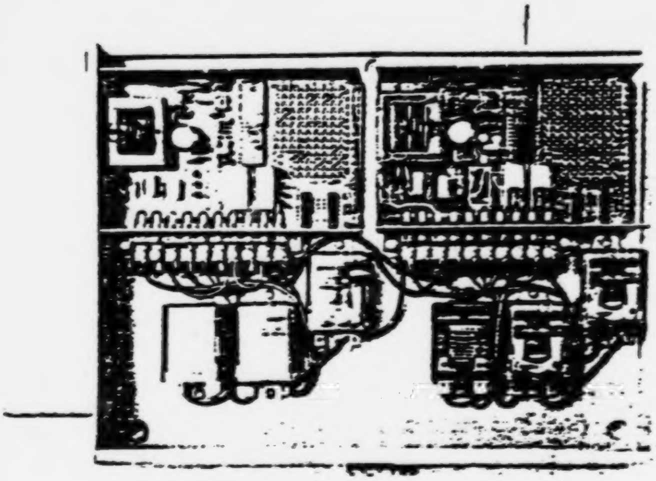
The AM broadcast radio receiver LCR 100/200 Series features an internal antenna (ferrite or loop) or an optional signal pickup from the power lines.



Three Load Control Receiver LCR 523-100 (1-30A, 2-3A) in standard injection molded plastic enclosure.



Single Load Control Receiver LCR 511F (1-3A) for controlling loads such as air conditioners, dual fuel furnaces, etc.



Six Load Control Receiver LCR 523-122X (6-30A) for controlling multiple high amperage loads such as baseboard heating.

---

6. Message Format "ricontic"

The message format used to communicate from the MCU to the remotely installed load control receivers consists of up to 50 data bits providing more than 20,000 discrete addresses, more than 10^7 in case of the LCR 200/600 Series' receivers.

Brown Boveri's internationally patented message format "ricontic" features a unique automatic stop bit: after the last information containing data bit one or more stop bits are transmitted automatically by the SIU. These stop bits reset all load control receivers instantaneously, thus allowing the transmission of load control commands only seconds apart. A typical load control message, therefore, takes only some 5 to 10 seconds to transmit.

The message format "ricontic" allows the addition of several load control commands to a single broadcast command. This enables the user to shed loads very rapidly. SCRAM (ALL OFF) commands may be transmitted in less than 5 to 10 seconds.

Alternately, BBC's load control receivers may be used as add receivers to non-BBC systems with other message formats.

7. Test Equipment

A variety of test equipment is available for in-depth system checkout and easy troubleshooting. The load management system is, of course, fully operational without any of the described test sets.

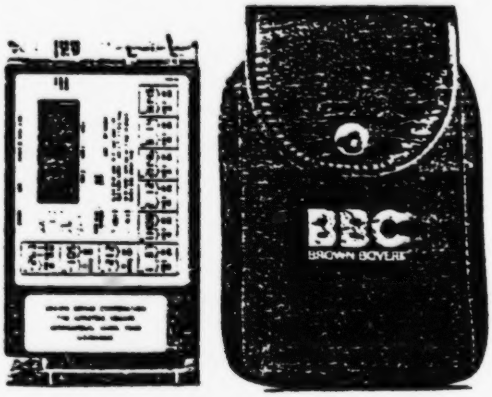
Telemetry System

The handheld, microprocessor based telemetry system test set T2027 is described in Section 3.

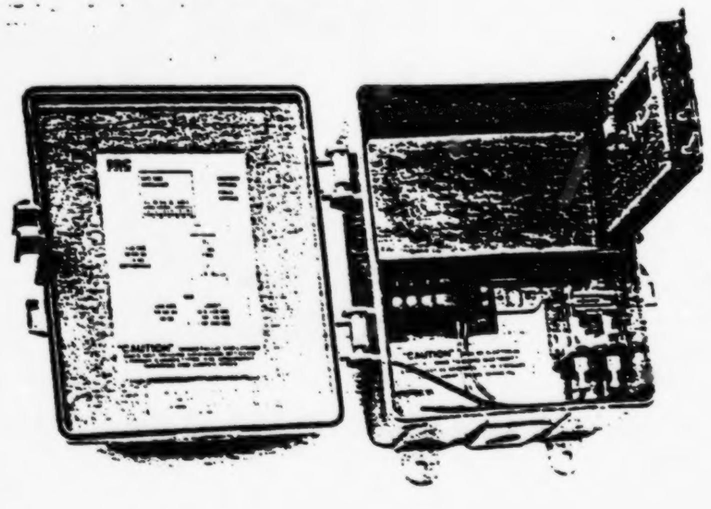
Pocket Size Receiver Test Set

The pocket sized test set LTS 560 provides the following functions:

- Readout and reset of integral operation counters.
- Display of currently received control commands from the MCU showing:
  (1) reception of a valid start bit
  (2) number of the currently received/expected data bit
  (3) reception of data bits
  (4) detection of any signal or noise pulses of the proper control frequency.
- Readout of receiver coding and address.
- Initiation of the test shed procedure: all load switches are turned-OFF and restored in one minute intervals. This allows the installer to immediately check the wiring to the loads and verify relay operations.
- Initiation of cold load pick-up sequence without disconnect of power supply.



Receiver Test Set LTS 560 with carrying case. The front cover the LTS 560 shows a brief summary of how to use the test set.



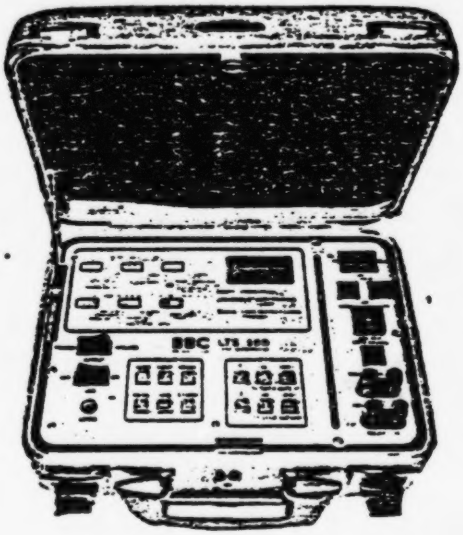
Single Load Control Receiver LCR 501-100 (1-30A) with optional sealable cover for the electronic compartment and the test set LTS 560 in place.

Load Control Receivers

The Data Logger LTS 554 is available to provide a timetagged hard copy printout of all receiver relay operations and all detected signal and noise times in milliseconds.

Portable Signal and Message Generator

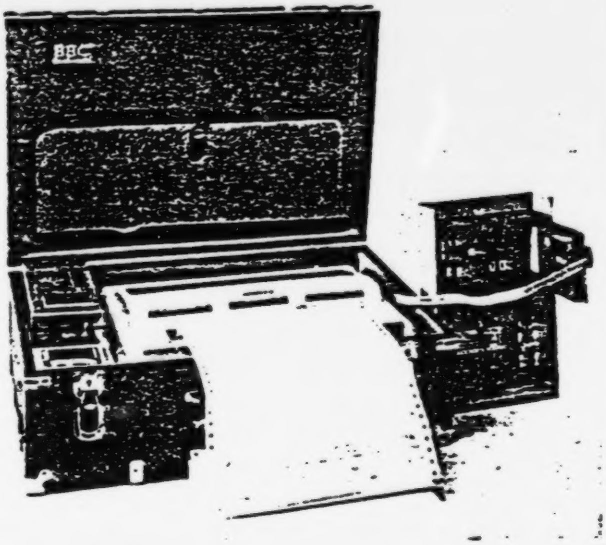
The portable signal and message generator LTS 550 generates all load control messages at the selected signal frequency for checkout of receivers at the installation site or on the bench. Long term receiver testing supported by a variety of automated test functions.



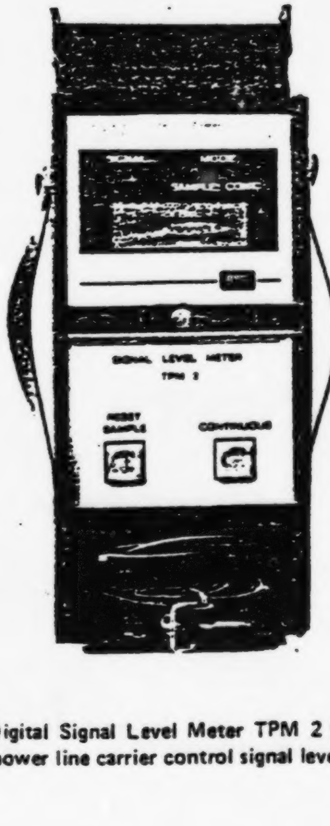
Portable Message and Signal Generator LTS 550 for storage and generation of any load control message, including transmission of control message sequences.

Portable Signal Level Meter

The digital multi-frequency signal level meter TPM 1 and the handheld digital signal level meter TPM 2 are available for verifying and recording PLC signal throughout the controlled system.



Data Logger LTS 554 with the test set LTS 560, provides a complete time histroy of load control communication activity as detected by a particular load control receiver. Here shown with the Three Load Receiver LCR 523-100S in standard sheet metal enclosure.



Handheld Digital Signal Level Meter TPM 2 for easy verification of power line carrier control signal levels.

CONTROL 80 SYSTEM

LOW FREQUENCY POWER LINE CARRIER

RM 815 RECEIVER METER

Landis & Gyr's RM 815 is the newest member of the CONTROL 80 receiver family. In a single, compact unit it provides both metering and centralized control of load for demand deferral.

GENERAL DESCRIPTION

The RM 815 integrates a low frequency power line carrier load control receiver and a kWhr meter under one meter cover and is compatible with a standard meter socket. It is a low maintenance unit that responds to CONTROL 80 load management system commands, providing both metering and load control for demand deferral.

SYSTEM INTERFACE

The RM 815 is one of the remote interfaces of the CONTROL 80 system. The RM 815 detects and decodes the individual, group and SCRAM commands that have been generated by the CONTROL 80 central programming unit and injected onto the power line as audio frequencies. When appropriate commands are received the individually metered load is controlled.

APPLICATIONS

The RM 815 has the designed-in reliability, long term stability, flexibility, and features essential for dependable, cost effective application in the electric utility environment. The RM 815 is an ideal replacement for meter based time clocks that are used to control water heaters. The RM 815 provides:

- Instant response to changes necessitated by PUC requirements, daylight savings time changes, seasonal load fluctuations, and holidays.
- Decreased operating and maintenance costs.
- Improved load factor and increased energy sales.

MECHANICAL DESCRIPTION

The RM 815 is compact, easy to install and requires no auxiliary power source (i.e., no battery back-up). It is supplied totally assembled in a standard weatherproof meter enclosure. The cover is made of frosted glass and is five inches deep. This compact construction is made possible by sandwiching the control receiver printed circuit board between the meter register and the Ferraris meter.

Conforming to industry standards, the RM 815 is compatible with ring and ringless sockets and plugs into a standard four blade or six blade meter socket.

FUNCTIONAL DESCRIPTION

The RM 815 combines the functions of a load control receiver and a single-phase watthour meter. The functions performed by the receiver meter are:

- Detecting and converting the injected audio impulses into a digital signal.
- Decoding the digital signals and insuring that the receiver only responds to a correct command.
- Operating the load control relay which opens one of the meter current coils.
- Measurement of the total kilowatt hours of the controlled load.

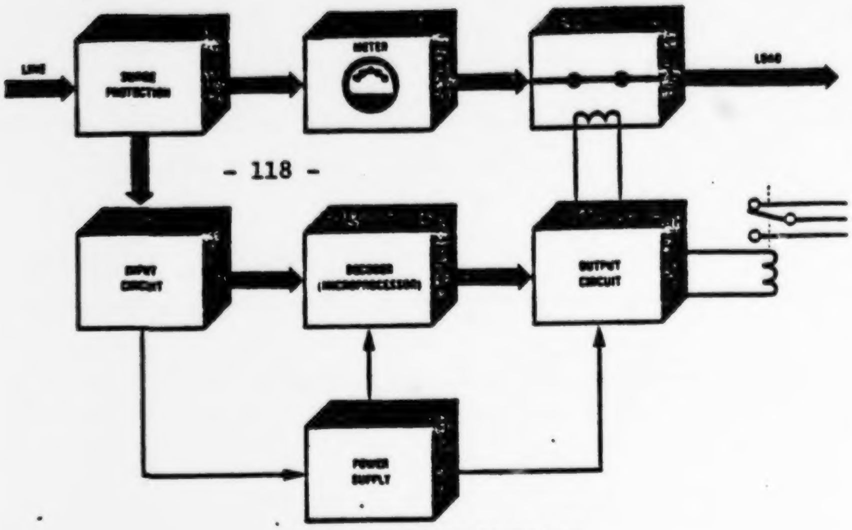
Refer to Bulletin R/E-US-806 for additional information.

LOAD MANAGEMENT™

LANDIS & GYR

MOORE SYSTEMS

Technical
Data
and
Specifications



RM 815 BLOCK DIAGRAM

GENERAL	
Industry Standards	
— Designed to meet	NEC Requirements
Input Voltage	
Supply Voltage	240 V, +10%, —15%
Frequency	60 Hz, +1%, —2%
Temperature Range	—30° to +60°C
Humidity	0 to 100% Relative Humidity
Housing	
Material	Glass
Weather resistance	Designed to NEMA Type 3 Standards
RECEIVER	
Power Requirements	
Standby	Less than 3.5 Watts
Operating	Less than 7.5 Watts
Addressing	
Coding	SEMAGYR 50 & 52, EdF 40 codes available
Number of addresses	Two out of more than 4,000
Programming	Address is programmed by switch selection without physical circuit modifications
Signal Input	
Frequency	220 Hz, 260 Hz, or 340 Hz
Response Sensitivity	0.5% of line voltage
Output Contact Ratings	240 VAC for 30 Amp load

METER SPECIFICATIONS

CLASS	FORM	TEST AMPS	VOLTS	WIRE	K_h	REG. RATIO	KWH REGISTER
200	2S	30	240	3	7.2	13 8/9	5 DIAL

Specifications subject to change as necessary to meet our customers' needs.

Technical Bulletin R/E-US-806

LANDIS & GYR

MOORE SYSTEMS

1730 Technology Drive
San Jose, CA 95110
(408) 297-9920
TWX 910-338-0217